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The Laminar Art

OF all the aphorisms with which Sir Frederick Handley Page has enriched the literature of aeronautics (and we may be thankful that his wit and vision continue unimpaired with the passage of years), few have so impressed themselves on our memory as did a pronouncement of his on laminar flow. The occasion was an H.P. senior staff dinner in London, and Sir Frederick had his audience in thrall with his visions of things to come. "We are on the edge of a great ocean of undiscovered truth," he said, "but we have got to learn to use the untapped stores of energy around us." The phrase that we especially remember was his likening the achievement of laminar flow to "fitting ball or roller bearings to an old cart with a squeaking axle and solid wheels."

In those homely but graphic words he pictured the very nucleus of the matter. Under the direction of the indefatigable Dr. G. V. Lachmann, his company's research department has propounded the theory in detail, following years'-long investigations at Radlett, and on page 14 we describe the gist of their enquiries into this fascinating and richly promising technique. We hope to pursue the subject in early issues, for it is clear that the laminar art has advanced significantly in recent months, especially in respect of swept surfaces. Already Handley Page are able to claim their ability and readiness to build an airliner with sufficient range to fly non-stop between Britain and Australia. This unorthodox strut-braced high-aspect-ratio, high-wing monoplane—one of three projects under consideration—would cruise at Mach 0.9. In strategic terms, it could over-fly all present "problem areas"; and it would carry more than 13 tons for 15,650 miles in still air.

Ranges of this order are, of course, well beyond the capacity of any transport—jet, turboprop, or piston-engined—in being or in prospect. So from that consideration alone, we must hope that the competent authorities who attended last week's laminar-flow symposium (and the Air Minister was among them) will have emerged stimulated by these new and auspicious British developments.

Moving Towards Missiles

IT has been suggested that Britain's future reliance on guided missiles may be unwise, and that during the 1960s we shall bitterly rue our lack of aeroplanes. America continues to spend immense sums to keep her squadrons of manned aircraft up to date. But what shall we in Britain have to match Weapons System 110A, the chemical-fuel long-range bomber capable of over Mach 3.5? Or WS-125A, the nuclear-fuel bomber which could fly 600 hours non-stop? Or WS-202A, the fantastic long-range intercepter family for six years hence?

The fact is that we have announced our intention of giving up trying to make such "systems." This means that our missiles must be of the very highest quality, and it is greatly heartening to know that quality is indeed characteristic of our first generation of anti-aircraft weapons—de Havilland Firestreak, Bristol Bloodhound and English Electric Thunderbird.

What of offensive missiles? First to come into service with British forces—excluding the American Corporal—will probably be Avro's stand-off bomb. Here we have something which should multiply by an incalculable amount the ability of Bomber Command to hit defended targets. Of the ballistic weapon, it is only possible to comment that it would be incredible if we were able to produce a weapon to the time scales of Atlas, Titan, Thor, Jupiter or Polaris. Possibly it is our intention to evolve a missile with particular qualities suited to our own purposes, and meanwhile to rely entirely on whichever IRBM (intermediate-range ballistic missile) we get from the U.S.A.

Apropos of which it is to be hoped that the M.P. who expressed concern over the failure of an Atlas on June 11 has now been reassured. Missile engineers are not dismayed to have an early firing end in a failure, for they can learn best from their mistakes. Moreover, Britain is not at present going to get Atlas, nor any other ICBM—so that we can merely play the part of interested spectators.

MORE BRITISH LIFT: Like Ryan's tail-sitting X-13, which has a Rolls-Royce Avon, Bell's new X-14 VTOL machine employs British lifting-jet engines. The two Armstrong Siddeley Vipers have special tail-pipes for deflecting the jet vertically downwards (news item, p.3).

FROM ALL QUARTERS

East-West Britannia

ONE of the longest east-to-west Transatlantic flights yet attempted—from London Airport to Vancouver non-stop—was made last Saturday by G-AOVA, the first Britannia 310. The aircraft left London Airport at 0807 hr B.S.T., and arrived in Vancouver 14 hr 40 min later, covering the 5,100 st m at an average ground speed of almost 350 m.p.h. The Britannia, flown by Walter Gibb, Bristol's chief test pilot, made this trans-Polar region flight as one of the route-proving series required for airworthiness certification. (Its special category C. of A. was awarded earlier this year.) The aircraft took off at its maximum gross weight with a payload of about 14,700 lb, including 38 passengers. Among them were Mr. Peter Masefield, Bristol's managing director, and representatives of A.R.B., B.O.A.C., C.P.A.L. and El Al. On the day following the landing at Vancouver, and while being towed, the torque links on the port main bogie were broken when the tow bar was taken beyond normal towing angles. A new leg was flown out and the aircraft was expected to continue its programmed visit to Boston before returning to Filton.

Avro Win Belgian Contract

FOR many months the Belgian Government have been evaluating numerous aircraft for selection as a standard all-weather fighter for the Royal Belgian Air Force. Their choice is the Avro CF-100 and the order is worth $43m (£15.4m). Financing will be undertaken by the Mutual Defense Assistance Programme.

Sir Roy Dobson, Chairman of Avro Aircraft, of Malton, Ontario, has pointed out that this is the first time that Canada has exported military aircraft of her own design. A spokesman for the Hawker Siddeley Group said that one-quarter of the purchase sum would represent spares and support facilities.

Comet 4Bs for B.E.A.?

A B.B.C. news bulletin on July 1 stated that B.E.A. are planning to operate a fleet of six Comet 4Bs as from 1959. No confirmation of this statement was forthcoming from B.E.A. or from de Havilland.

The possibility that the Corporation, notwithstanding its strong turboprop inclinations, will need a jet to maintain its competitive position has been evident for some time [see *Flight* for February 8 and May 31]. The specialized 600-m.p.h. short-haul jet (to which a new reference is made on page 30) could not be ready before 1963.

Whatever substance there may be in the latest report, which makes obvious sense particularly in view of the S.A.S. order for Caravelles reported in this issue, it is likely that B.E.A.'s jet procurement programme, interim and long-term, will be resolved within the next 30 days.

Firestreaks in Australia

BRIEF notes on the test firing of Firestreak, the British air-to-air weapon developed by de Havilland Propellers, Ltd., were contained in an announcement made last week by Mr. Howard Beale, the Australian Minister for Supply.

During the past two years, said Mr. Beale, the Weapons Research Establishment at Woomera had conducted extensive trials of Firestreak and a very successful series of "kills" had been achieved. The Firestreaks had generally been launched from Australian-built Avon-Sabres and the targets had been Jindiviks of the R.A.A.F. M.o.S. acceptance trials were now in progress.

A point of particular interest arising from this statement is the ability of the Sabre to carry two Firestreaks and their associated weapon-system equipment. De Havilland Propellers state that the weapon can be made readily adaptable to "any fighter aircraft," the combat performance of which is markedly increased, particularly during engagements at great range from astern or from lower level. The Firestreak/Sabre combination seems to be exceptionally effective and may be widely adopted by numerous air forces once the weapon is cleared for operational service.

Fairey Flying Appointments

TWO new executive flying appointments have been announced by the Fairey Aviation Co., Ltd. G/C. Gordon Slade, formerly chief test pilot, becomes superintendent of flying; and Mr. Peter Twiss is appointed chief test pilot. In his new capacity G/C. Slade, who joined Fairey's as chief test pilot in 1946, will be responsible to the chairman and managing director, Mr. Geoffrey W. Hall, for the co-ordination of all flying activities within the company.

May Aviation Exports

DURING May exports by the British Aviation industry amounted to almost £10.4m. This figure is the highest achieved so far in 1957, more than £2m up on the total for May last year, and the third highest monthly total recorded.

Aircraft and parts exported amounted in value to £6,421,577; aero-engines to £3,378,589; electrical parts and components to £306,712; tyres to £50,150; and aeronautical instruments to £208,997. The S.B.A.C. reports that the total of aircraft exports for the first five months of 1957 amounted to £42.9m.

Talos Develops

AT the end of World War 2 Project Bumblebee, undertaken for the U.S. Navy by the Applied Physics Laboratory of the Johns Hopkins University, Maryland, was instituted with a view to determining the requirements for a ship-to-air guided weapon. Most of the earlier work on Bumblebee was directed towards missiles with integral ramjet propulsion and by 1950 the basic vehicle was behaving very well. Nevertheless it was clear that a missile powered by a solid rocket could be got into service much quicker than the longer-ranged ramjet, and Terrier was accordingly developed and has since been mass-produced for four years.

BEMBRIDGE-BUILT: This Druine Turbi, the first to be completed in this country, was constructed by Britten Norman, Ltd., for the Popular Flying Association. The aircraft is powered by a 65 h.p. Coventry Victor Flying Neptune, and sports the blue and primrose P.F.A. colours.

Designated the Talos SSM-N-6, the ramjet weapon is now following the rocket-propelled Terrier into service with the U.S. Navy. Powered by an integral 30in diameter motor—which, like the airframe, is manufactured by McDonnell Aircraft—Talos has annular kerosine tanks and space for a large warhead of either the H.E. or nuclear variety. Unlike Terrier, the beam-riding cruise guidance switches to semi-active homing for the terminal phase. Eight flush strip metal aerials are disposed axially around the nose, and four probe aerials project ahead of the double-shock nose intake.

During firings from White Sands, Inyokern and other test establishments, Talos has demonstrated excellent reliability and accuracy at ranges up to about 40 miles, and has proved so successful that introduction to the Fleet is being accelerated. The intermediate sea-going trials are being eliminated and the first ship installation will be operational: Talos will form the primary armament of the light cruiser *Galveston* which is now being converted. Later, two other cruisers, *Little Rock* and *Oklahoma City*, will receive Talos armament, and the weapon will also be used on the nuclear-powered cruiser *Long Beach*.

There are already several varieties of Talos and later versions will use high-energy fuel. It is possible that the U.S.A.F. and Army will combine to use Talos in various land-based functions, and the weapon can also be used against surface and ship targets. Prime contractor is Bendix, who deliver complete rounds from the Naval Ordnance Plant at Mishawaka, Indiana; ground radar is the prime responsibility of R.C.A.

[A photograph of a Talos missile before firing at White Sands is published on page 6.]

Into the I.G.Y.

LAST Monday, July 1, was the start of the International Geophysical Year, in which all major nations are co-operating in an unprecedented manner in order to accelerate our acquisition of knowledge of all things affecting the earth as a whole.

On June 27 it was announced that a second Skylark ("CTV Gassiot vehicle") upper-atmosphere sounding rocket had been launched at Woomera. Developed at the R.A.E. [and briefly described in *Flight* for September 14, 1956, page 489], Skylark is powered by a Raven solid-propellant motor delivering 11,500 lb-thrust for 30 sec.

The first Skylark was fired on February 13 with a relatively flat trajectory. The second, launched last week, was fired from its pivoted 80ft launcher at "an intermediate angle"; during its five-minute flight Skylark No. 2 rose to more than 50 miles, exceeded 2,500 m.p.h. and travelled some 120 miles horizontally. When fully developed the Skylarks are expected to carry 65lb of instrumentation to a height of 100 miles. Most of the firings will probably be in the Antarctic.

Across the City in Eighty Minutes

ON Wednesday last week the producers of *Round The World In Eighty Days* arranged an ascent of the balloon *La Coquette* from the Battersea Pleasure Gardens, London. The cast included Mrs. Constance Wolf, pilot, Mr. Anthony Fairbanks, crewman (both members of the American Balloon Club), and Mr. Francis Shields, crew chief, fresh from the recent balloon race in Holland; while crowd background was provided by the Press, the Metropolitan Police, the London Fire Brigade, the L.C.C. and the Royal Aero Club, most of whom had co-operated, with M.T.C.A., to make the ascent possible. In overall charge was Mr. Mike Todd, director of the film.

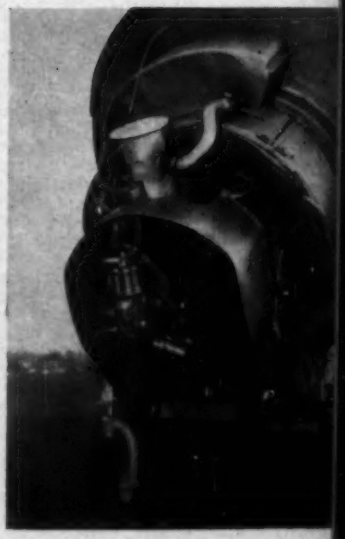
Final preparations were made to the accompaniments of draughts of hot coffee brought in an enormous Daimler and a Land Rover. When all was ready, a radar reflector, supplied by the Meteorological Office for the benefit of London Radar, was attached and the 19,000 cu ft balloon floated slowly upwards. Mr. Todd confirmed that they were not insured against striking Buckingham Palace and shouted to Mrs. Wolf to turn the balloon round so that the crowd could see the registration, N9074H, the official requirement for which greatly amused him. But *La Coquette* (living down to her name) sank rapidly into nearby tree-tops. Sand ballast was urgently shed, apparently on to the heads of the crowd, and *La Coquette* got away leaving her radar reflector in a tree.

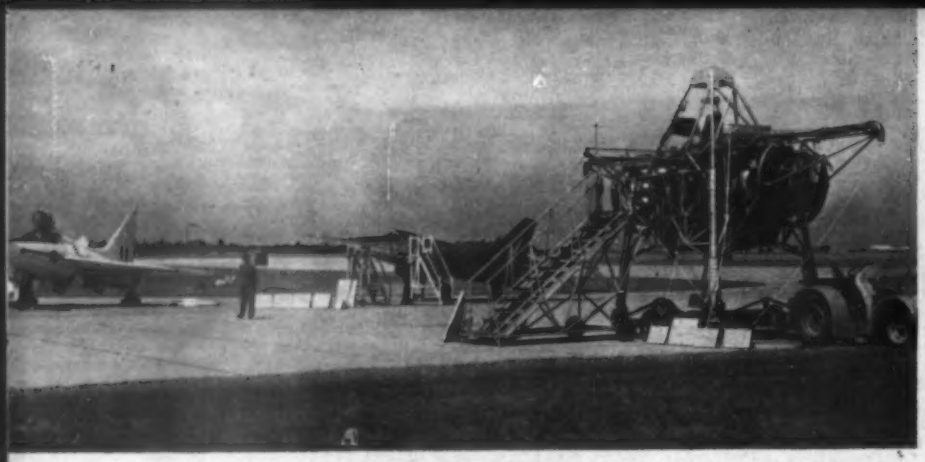
Mr. Todd's instructions were that Mrs. Wolf should *"ad lib* it" for two hours in the prevailing wind and then land, with due circumspection, somewhere in the Stapleford Tawney area; M.T.C.A. required that *La Coquette* should not ascend above 2,000ft. So she drifted away over Pimlico and St. Paul's (apparently obedient now) and was lost to view. The *ad lib* flight plan was faithfully followed and, in due course, *La Coquette* alighted safely in a clearing in Epping Forest.

Bell X-14 Successful

ON June 27 the Bell Aircraft Corporation announced the successful completion of initial flight testing of the X-14, a jet VTOL machine for the U.S. Air Force. Powered by two Armstrong Siddeley Viper turbojets with special tilting nozzles, it has a relatively conventional configuration, with a span of 34ft, a length of 25ft and a height of 8ft including the fin. Take-off and landing are effected in the normal attitude and for hovering and low-speed control air nozzles are fitted at the wing tips and tail. Most of the problems of controlling such aircraft were solved with the earlier Bell Model 62 of 1955 (described in *Flight* for February 11, 1955).

***WHIRLWIND HAS.7** is the designation of the Navy's new anti-submarine helicopter, first deliveries of which were reported last week. Above, the weapons bay is just visible. Left, Mr. E. C. Wheeldon, managing director of Westland Aircraft, Ltd., hands over log books to Lt. Cdr. Sproule, officer commanding No. 700 Squadron Helicopter Flight. Right, installation of the Alvis Leonides Major engine.*





In the static park before the flying demonstration, the Boulton Paul P.111A, the Fairey Delta 2 with a special high-speed paint finish and the Rolls-Royce Flying Bedstead.

Opening Day at Bedford

Flying and Static Displays

THE new R.A.E. installations and airfield at Thurleigh, near Bedford, were officially opened on June 27 by Mr. Aubrey Jones, the Minister of Supply. The ceremony took place in the rigging room of the 8ft×8ft supersonic wind tunnel (which, together with the other wind-tunnels, is described in an article on pages 18-20). Mr. Jones said that it might be suspected from the Defence White Paper that the £30m spent on building this great new establishment had been wasted. But he pointed out that new research facilities were still needed if Britain was to continue to strive for mastery in the aeronautical field, as she had to do. In addition, the aircraft industry to some extent led the remainder of the country's industry with its special requirements. We could not halt progress at a given level, say at Mach 2, for progress in the design of either manned or unmanned aircraft would then come to an end—and that was unthinkable.

Manned aircraft would in any case be required for as long as could be foreseen, since missiles lacked those qualities of flexibility which were the peculiar advantage of manned aircraft. The latter would continue to be needed for reconnaissance, transport, defence at the distant horizon and tactical bombing in limited war. Only for close defence and strategic bombing would missiles take their place. The Bedford facilities were at the disposal of the industry; and many important personalities had been invited so that they might see for themselves what was available.

Mr. Jones complimented the 700 contractors who had helped to build the installations; and finally declared the establishment open by unveiling a commemorative plaque in the rigging room. A Pye television film of a typical run at Mach 1.6 in the adjacent tunnel was then shown on a closed-circuit system set up for the occasion.

The opening ceremony was attended by almost all the leading personalities in the aviation industry, the Services and interested Government departments; also by some representatives of foreign companies and agencies. The Chief Superintendent at R.A.E. Bedford is Mr. L. H. G. Sterne, who is also head of the Naval Air Department. Other divisional heads are Mr. J. S. Thompson (Wind Tunnels) and Mr. Roger Duddy (Aero Flight), both of whom are responsible to Mr. L. F. Nicholson, head of the Aerodynamics Department at R.A.E. Farnborough; and Mr. W. J. Charnley (Blind Landing Experimental Unit). The research divisions are backed up by Service departments headed by Mr. R. R. Pattison (Superintendent of Engineering), W/C. H. G. Larsen (O.C. Flying) and Mr. H. E. Stockwell (Chief Administrative Officer). Ministry of Works engineers responsible for the civil-engineering and mechanical/electrical engineering aspects of the establishment are Mr. C. J. Rigby and Mr. T. Barnes respectively. A total of approximately 1,450 people are employed at the establishment, of whom 1,200 are M.o.S. staff.

Particularly noticeable in the wind-tunnel workshops were several models of a narrow delta wing featuring a sharp leading-edge and a thick root section.

Some of these were being tested in the low-speed tunnel. The peculiarity of this wing arrangement is that, in any positive angle of attack, a spiralling vortex builds up above each leading edge and this gives better lift characteristics than the normal lifting airflow. Leading edge sweep on the models shown was of the order of 75 deg. Aspect ratio was about 1.3. Good behaviour had been found throughout the lift range (present tests are being taken up to flow speeds of 300 ft/sec), and subsonic flow characteristics were expected to be maintained at airspeeds above Mach 1. It was stated that the wing form was not connected with any specific project.

On Thurleigh airfield, some miles up a specially built approach road which would have done credit to Europe's best road builders, an exhibition of aircraft and equipment was arranged. A Sea Vixen fitted with a hefty, striped refuelling boom was launched—after an exceedingly high-boosted run—on the raised steam catapult platform. This was the first public demonstration of the only land-based steam catapult on this side of the Atlantic. A Sea Hawk was also launched in this way and then landed into arrester wires rigged across a runway. The aircraft was still airborne, though its hook was dragging along the ground, when it caught the wire. It stopped relatively smoothly in about 30 yd. The Naval Air Department show was concluded with the attempted arresting of a Meteor 7 in a nylon-strop emergency barrier. But the Meteor got the better of it and tore the device to shreds with a satisfying rending noise. Entry speed appeared to have been about 40 to 50 kt, but a high power setting was retained until well after the Meteor met the barrier. The only damage to the aircraft appeared to be a dent in the leading edge of its fin.

The second English Electric P.1A (WG763) took off, flew past several times and then landed with the aid of a very large ribbon drag-chute which buzzed loudly as these devices often do nowadays. Boulton Paul's P.111A, the "yellow peril," cavorted overhead. It has been based at Bedford for some time and is now used to investigate the cross-coupling of inertia moments during fast manœuvres. A Fairey Delta 2, sister to the record-holder, made a goodly double sonic boom and displayed the new dark-blue high-speed paintwork which is now experimentally applied to the fuselage aft of the hingeing nose. This machine is being used to investigate the temperature rise at supersonic speeds as well as for general investigation into the handling characteristics of a 60 deg-swept delta. A Varsity and a Canberra T.4 of the Blind Landing Experimental Unit respectively demonstrated a fly-past holding a height of 20ft with the radar altimeter (by Standard Telephones and Cables, Ltd.) and an automatic approach using a magnetic leader-cable, buried underground, for directional guidance during the final approach.

The Short S.B.5, painted dark blue and black, was in the static park, together with its original high tailplane tail unit. It carried equipment for recording airflow at low speeds by photographing smoke passed over the wing from a canister attached to one of a series of angle-plates mounted parallel to the leading edge and just aft of it. A large metal tube-mounting was attached aft of the port aileron to hold a pressure-sensing rake. Ballast tanks were also shown ready for attaching to the wing for investigation of rolling behaviour at various inertial load values. Another feature was the notch cut in the leading edge to stabilize the vortex over the wing. This prevents wing-dropping at low speeds and improves directional stability. The notch, now also fitted to the P.1, is 3in

Left to right, Mr. George Gardner, Director of the R.A.E., Mr. Aubrey Jones, Minister of Supply, and Mr. L. H. G. Sterne, chief superintendent of R.A.E. Bedford and head of the Naval Air Department, after the opening ceremony.

D.H. Sea Vixen XF 828, shown fitted with a massive striped refuelling probe, under-wing pylons and bulges under the fuselage just aft of the radome. The wings of this particular aircraft do not fold.

"FLIGHT" PHOTOGRAPHS

wide, 6in. deep and is located at 70 per cent of each semi-span.

Another high-speed investigation was shown by a Hunter which has been area-ruled by application of a large lateral bulge on each side of the fuselage, just aft of the wing. Significant reductions in drag were obtained with no change in handling characteristics; but since these were recorded at speeds above the thrust-limit level, no increase in maximum level speed was achieved. This same machine had been used to photograph shock-wave patterns indicated by light refraction in natural sunlight over the wing. Highly viscous oil had also been spread over the wing to photograph airflow-stagnation points, but this method had not proved as successful as in similar American work.

Low-speed research was represented by the jet-deflection, Nene-powered Meteor, whose stalling speed had been reduced by 20 kt at approach power setting with 60 deg deflection. A blown-flap Sea Venom was also there, showing extensive tufting and the exceedingly fine slot in the leading-edge camber of the flap through which compressor-bled air is blown at supersonic speed. Stalling speed at approach r.p.m. had been reduced from 88 kt to 75 kt. The tip-tanks had been filled with varying amounts of liquid ballast to test the rolling power of the ailerons.

An intriguing machine was a Venom N.F.3 used as a pacing aircraft. It carried accurately calibrated height- and speed-measuring instruments and three alternative pitot heads. It also had a "bird," stowed under the fuselage, which could be lowered some 70ft into undisturbed air from an electric winch in the cannon bay. This Venom is intended to calibrate the pressure instruments of other aircraft.

A Meteor T.7 with a large striped nose-boom, exhibited in the static park, is used for experimenting with a very rapid method of evaluating the stability characteristics of an aircraft. With the new method, accurate measurements can be made in ten minutes which would require ten hours' flying with traditional techniques. Another Meteor, an F.8, was being flown with an electronic device which controlled the elevator trim tab in much the same way as an auto-pilot, but in the opposite (de-stabilizing) sense. The purpose was to determine minimum safe and acceptable longitudinal stability characteristics. This is because some aircraft which are suitably stable at one part of the speed range become much less stable in others. A sure knowledge of the minimum acceptable stability allows the provision of the best compromise in flight characteristics to cover the whole speed range. The Rolls-Royce Flying Bedstead was on the airfield, but the wind was too strong for a demonstration flight to be made.

An extensive exhibition was laid out in one of the three large hangars at the Aero Flight site. Two Hunters were shown fitted respectively for determination of moments of inertia in a static rig and for measurement of tailplane loads and airflow distribution in flight tests. The Murphy Rebecca Mk 8 and Babs Mk 4 were on view. They are respectively the airborne and ground elements of the new combined distance-measuring and heading-indication equipment which can handle 50 aircraft at a time and is claimed to be the first pilot-interpreted precision-approach aid fitted in single-seat aircraft. Rebecca Mk 8 has a range of 20 miles at 2,000ft and is standard in the Hunter 6. Smiths' S.E.P.2 autopilot and the associated Flight System integrated instruments were displayed, as was the Standard Telephones and Cables radio altimeter. The last-named uses F.M./C.W. radar and has indicating ranges from 0-500ft and 0-5,000ft. A special delay line attached to the aerial system allows accurate functional checking of the equipment against the sample altitude reading produced by passing the normal sensing signal through the delay line.

The Naval Air Department was strongly represented in the static display with carrier models and a scale-model arresting-gear installation. The TRODI (Touch-down Rate of Descent Indicator) for instantaneously measuring rates of descent during carrier landings was described; and the companion device for measuring touch-down forward speeds was demonstrated. It consists of two light-sensitive elements which, "looking" across the landing area, instantaneously measure the time between the cutting of the first and second lines of sight by the shadow of the aircraft.

Another device was a cross-pointer instrument for helicopter blind-flying which gives the pilot visual instructions for stabilizing his machine. The cross-pointer needles are regulated by integrated displacement and rate-of-movement indications derived from attitude and rate gyros. The pilot therefore acts much like the servos of an autopilot, by being instructed to damp out disturbances almost as soon as they begin. He simply has to keep the needles crossed centrally to maintain a stable attitude. This system is much easier to use than a plain artificial horizon.

Other Naval items on display were concerned with the assessment of fields of view from projected aircraft cockpits at various ranges from model carriers. The mechanics of the slotted tube mechanism of the steam catapult were also shown in full-scale cut-away models.

All these exhibits showed—for the first time since the notable Farnborough Jubilee exhibition two years ago—the present general direction of R.A.E. work. There appears to be no slackening in research in the fields of manned aircraft and their equipment.

The area-rule bulges of the experimental Hunter which was also used for photographing shock-wave patterns by sunlight.

The Sea Hawk just leaving the steam catapult mounted on the five-foot-high platform which simulates a carrier deck. A speed of 150 kt is reached in some 200ft.

HERE AND THERE

PEMBROKE Mk 54 is the designation of this handsome Hunting Percival production for the West German Air Force. First of a substantial number (reported in Bonn to be 33) it was delivered on June 22 by Hauptmann J. Thurnhuber. The remainder of the contract are well advanced at Luton.

S.B.A.C. Elections

THE Council of the S.B.A.C. has elected Mr. C. F. Uwins to continue as president of the Society for 1957-58, with Mr. A. F. Burke again as vice-president. Mr. J. J. Parkes, who was president in 1954-56, continues as deputy-president and Sir Frederick Handley Page has been re-elected honorary treasurer.

Russia's Diskoplan

SHAPED like a discus, and known as the Diskoplan, is a new glider recently tested at Tushino "with great success." The span is given as 3½ metres, the wing area as 10 sq metres, and the lift is said to be "sufficient to carry a load of 230 kilograms." The pilot's cockpit is beneath the "discus," with the rudder and elevators above and astern. "Neck-breaking aerobatics" are said to have been performed with the greatest of ease, and the purpose of the glider is said to be the study of the stability of similarly shaped aircraft.

S.A.C. Command

AT Offutt A.F.B., Nebraska, on June 25, Lt-Gen. Thomas Power took over command of the U.S. Strategic Air Command from Gen. Curtis LeMay, who has been promoted to Vice-Chief of Staff of the U.S.A.F.

Secret Salvage

LAST week an "object," unofficially claimed to have been a pilotless aircraft, came down in the sea off The Lizard, Cornwall. The device was stated to have been launched from a "closely guarded research airfield," which local reports announced as Predannack, adding that teams of scientists and engineers made strenuous attempts to recover the device without attracting too much attention. Eventually the object was recovered by the Royal Navy. At least one newspaper ascribed the manufacture to Vickers.

Tracking the Missiles

FROM Baltimore the U.S. Air Research and Development Command announced recently that six telemetry ships—to track American long-range missiles—will soon be at work in mid-Atlantic. They will track the missiles across 3,000 miles of the 5,000-mile test range, which extends in an arc from Cape Canaveral, Florida, to Ascension Island.

Skeeter Contract Signed

A CONTRACT for ten Saunders-Roe Skeeter helicopters, ordered for the armed forces of the Federal German Republic, has been signed in Coblenz by the Federal Minister of Defence and a representative of Saunders-Roe, Ltd. [The Skeeter's flying qualities are described in an "In the Air" article on pages 15-17 of this issue.]

U.S.A.F. in Spain

HEADQUARTERS of the U.S. Strategic Air Command's 16th Air Force—the first to be based in Europe—were set up in Madrid on Monday with Maj-Gen. H. K. Mooney as commanding general. This follows a ten-year agreement, signed in 1953, entitling the United States to build and operate air and naval bases in Spain.

Messerschmitt Revival

AN official of the Messerschmitt company said in Augsburg last week that it is to re-start aircraft production next November. Initally it will build 210 Fouga Magister jet trainers for the West German Defence Ministry, employing from 800 to 1,200 people for from three to four years. At first the firm will merely assemble parts supplied from France, but next year will start making the parts themselves.

Woomera Expands

LAST Friday, June 28, it was announced in Canberra that the Long Range Weapons Establishment and missile range at Woomera has been appreciably extended. The extension is not in the principal line of fire across the Indian Ocean but apparently laterally, to embrace "thousands of square miles" of South Australia to which access is now prohibited. It was unofficially averred that the extension presaged testing of a British IRBM.

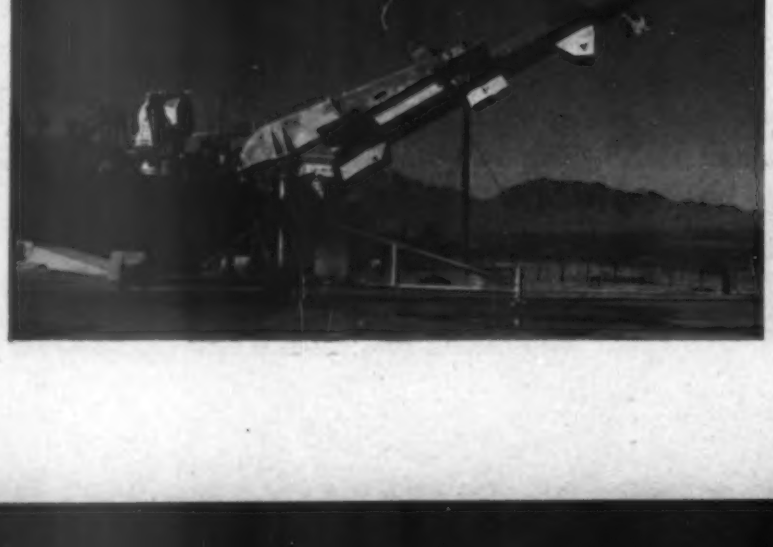
Award for Col. Balchen

IN Washington last week Col. Bernt Balchen, who in 1929—as Admi. Byrd's chief pilot—became the first man to fly over the South Pole, was presented with the "Outstanding Aviator" Award by the U.S. National Pilots Association. During the last war Col. Balchen, by birth Norwegian but now a U.S. citizen, served with both the R.A.F. and the U.S.A.F.

Sanity Clause

AMERICAN airline company "A" asked U.S. Government department "B" to make a final decision on a request which had been tentatively refused. "B" then accused "A" of "in substance seeking reconsideration of the adverse tentative vote to defer decision." "A's" request was in fact defined as "an anticipatory petition for reconsideration which is not properly fileable."

NAVAL ARMAMENT: A shipboard-type Talos surface-to-air missile before firing at White Sands Proving Ground, New Mexico. Notable features are the probe aerials around the nose, the movable wing cruciform, the fixed rectangular fins and the large solid-propellant boost motor.



TANK TUG: Tilted at 45 deg, a Vertol H-21 helicopter tows an M-48 tank during a recent demonstration at Fort Rucker, Alabama.

Agricultural Implements

Agricola and E.P.9 Developments

BOTH the Auster Agricola and the Edgar Percival E.P.9 are now established in service and deliveries to customers abroad are continuing. The two companies are nevertheless proceeding with development in order to adapt the aircraft for an ever-increasing range of agricultural and general duties, and pictures on this page show successful operations and tests recently carried out.

At Stapleford Tawney, the Percival airfield, bales of hay were dropped from the freight door of the E.P.9. For this purpose the aircraft was flown with the rear door removed; and Capt. Percival, designer and test pilot, reports that the handling characteristics are in no way impaired by this. The ability to air-drop supplies and material in this way is of course an important asset for the E.P.9. If required, materials can also be carried under the wings in special containers and dropped under the direct control of the pilot.

Another E.P.9 development is the rearranged spraying gear, also illustrated here. Spray-bar and tank layout remain as before, but the wind-driven pump has been moved somewhat further back under the fuselage with a resultant improvement in appearance and reduction in aerodynamic drag. The performance of the pump has not been affected.

Auster's chief designer and director, Mr. R. E. Bird, is now in New Zealand visiting all Agricola operators there and has received excellent reports of performance. In the picture at the top of this page an Agricola belonging to Airlift (N.Z.), Ltd., is shown dropping basic slag in the Ohariu area. On this particular day the machine was being flown from a 60ft-wide strip in a 30 kt cross-wind, lifting 15 cwt of basic slag at each take-off. Mr. H L. McGregor, Airlift director, is reported to have said that the Agricola "can outfly anything".

During tests at their factory airfield at Rearsby, Leics, Austers have found that basic slag is one of the worst materials to drop. They report that "it has a natural tendency to pack down hard in the hopper as it appears to have a slightly sticky consistency. The material itself is very fine, rather like sand mixed with soot." The design of the Agricola hopper combines with the slipstream to spread basic slag in an even flow. Reports from New Zealand state that this material even clogs the lorry loaders which have been in use for years there.

Auster have also carried out intensive tests to ascertain the flow characteristics from the hopper of a variety of materials, including superphosphate in dust and pellet form, basic slag, gypsum, wheat—and gravel, though this was used only to simulate full loads for prospective customers making trial flights. Tests have also been made with filler dust, used as a diluent to obtain very low rates of chemical deposit per acre without reducing the actual mass flow from the hopper to impracticably low levels. An interested Dutch company required trials in dropping bull-rush seeds and presented Austers with a special headache. The seeds in bulk resemble the filling of a pillow and consist of a rather stalky material with seeds attached. This capability was sought because, after a tract of land has been reclaimed from the sea, bull-rushes are first sown to dry out the land before it is cultivated.

On the left, an E.P.9 showing the rearranged spraying gear; on the right, hay-dropping at Stapleford Tawney; and above, an Agricola disbursing basic slag in the Ohariu area of New Zealand.

The Comparative Economics of

By R. M. Clarkson, Director, the de Havilland Aircraft Co., Ltd., and D.

WHEN a number of propeller-turbine and jet aircraft are examined—and there is abundant published information available to permit this—it is found that their economics all lie very close together. The very fact that the question of their comparative economics is so controversial at the present time is in itself a proof that the margin between the two types is small. This situation naturally raises the question: "Is this a fortuitous state of affairs arising from particular circumstances, or is it fundamental?" We were therefore prompted to break down and dissect the relevant ingredients of the operating cost of both types of aircraft.

Many comparisons have been published which are based on completely imaginary aircraft designed especially for the purpose. Some of these designs involve considerable extrapolation of the trends of aircraft and engine progress and some of the assumptions are questionable, particularly when they result in an aircraft which is very much more efficient than present-day designs. In order to overcome these drawbacks, we have based our comparison on aircraft of the standard of those which are now being offered to enter service in the period 1959-1962, and from these we have defined typical hypothetical aircraft for which we can fairly claim a factual basis.

The operation is considered over stage lengths of 250, 500 and 2,500 statute miles. None of the large aircraft at present being offered has been designed specifically and solely for operation over stage lengths of around 500 miles; therefore, the typical hypothetical aircraft which are considered here for operation on stage lengths of 250 and 500 miles are actually capable of flying distances of up to about 2,500 miles with capacity payload, and their operating costs on the shorter stages are not quite as low as those of more specialized aeroplanes would be. Similarly, the 2,500-mile stage has been selected as being representative of the routes on which the long-range aircraft will generally be used.

For the above reasons the same typical propeller-turbine is considered on all three stage lengths, while, in the case of the jet, the only difference is a small increase in thrust (for given payload) over the longest stage in order to maintain a reasonable take-off performance.

Derivation of Typical Aircraft. It can be shown that the direct operating cost is dependent upon a number of factors defining the properties of the aircraft. These may be grouped as follows:—

(A) Engineering quantities, which define the technical quality of the aeroplane: payload carried per pound of airframe weight and per pound of all-up weight; thrust or power loading at take-off; and ton-miles of payload per gallon of fuel.

(B) Specific first costs: airframe cost per pound of weight; jet engine cost per pound of thrust; and propeller-turbine engine-plus-propeller cost per e.h.p. (These quantities are dependent on production quantity, methods of financing, and so forth.)

(C) Operational economic factors, which are dependent on the environment in which the aeroplane is operated and the operator's accounting procedures: fuel cost; obsolescence period and residual value; spares holding; utilization, etc., as specified in the operating cost method employed for the calculation.

The quantities in Group (A) have been plotted for all the aircraft due to go into service in the period considered. The payloads used have been based on first-class layouts with a seat pitch of 38in to 40in, passengers being seated four-abreast in fuselages of under 12ft in diameter, and five-abreast in fuselages of 12ft or more in diameter.

From these plottings, representative mean values for each of the engineering quantities have been obtained for each of the three stage-lengths. Similarly, average figures of specific first costs have been selected, the airframe cost per lb of weight being the same for both jet and propeller-turbine types. It is assumed that each aircraft carries 100 passengers with an average proportion of freight. This gives a capacity payload of 29,000 lb, made up as follows:—

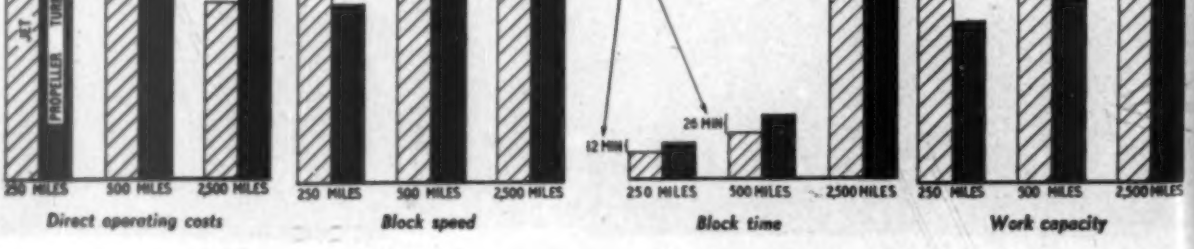
100 passengers with baggage, at 209 lb	20,900 lb
Freight	8,100 lb
	29,000 lb

The main characteristics of these hypothetical typical aircraft when operated over the various stage lengths are given in Table 1. On the 250 and 500 mile stages, both aircraft are assumed to be cruised at the speed and altitude for minimum block time rather than for best fuel economy.

TABLE 1

Aircraft	Jet			Propeller-turbine		
	Medium range		Long range			
Airframe weight (lb)	79,500		79,500	73,000		
Gross wing area (sq ft)	2,350		2,350	2,200		
Take-off static thrust (lb)	46,100		48,300	—		
Take-off power (e.h.p.)	—		—	22,900		
Cruising speed (m.p.h.)	590		550	410		
Airframe cost (£)	952,000		952,000	874,000		
Engine cost (£)	198,000		208,000	217,100		
Propeller cost (£)	—		—	38,900		
Total first cost (£)	1,150,000		1,160,000	1,130,000		
Stage length (miles)	250	500	2,500	250	500	2,500
Take-off weight (lb)	150,000	156,000	191,000	133,000	137,000	170,000
Block speed (m.p.h.)	342	425	500	268	310	380
Block time (hours)	0.73	1.18	5.00	0.93	1.61	6.58
Take-off aerodrome length (ft)	4,800	5,200	7,800	4,150	4,300	6,950
Landing aerodrome length (ft)	5,750	5,750	5,750	5,200	5,200	5,200
Fuel consumed (lb)	11,300	17,300	52,300	6,100	10,100	43,100

Take-off aerodrome lengths are in sea level I.S.A. +15 deg C. conditions; the landing aerodrome lengths are in sea level I.S.A. conditions to the U.S. 60 per cent rule.



Direct operating costs — *Block speed* — *Block time* — *Work capacity*

# of Jet and Propeller-Turbine Operations

and D. R. Newman, Chief Technician, Aerodynamics Department

DURING the past few months our columns have dealt at length with contributions to the jet v. turboprop economics controversy. Here, as foreshadowed in a leading article last week, is the case for the jet transport—presented by de Havilland.

On the 2,500 mile stage it is assumed that the jet would be cruised at a more economical speed—about 550 m.p.h. In the case of the propeller-turbine there is no appreciable change in operating cost with speed, and it therefore seems likely that it would always employ the fastest cruise procedure unless range is limiting.

Direct Operating Cost Comparison. Using operational factors appropriate to a slightly modified S.B.A.C. method,* the relative direct operating costs per ton-mile of the above jet and propeller turbine aircraft are found to be as follows:—

250 miles stage, the jet is 6.9 per cent above the propeller-turbine;
500 miles stage, the jet is 1.6 per cent below the propeller-turbine;
2,500 miles stage, the jet is 12.0 per cent below the propeller-turbine.

There is considerable scatter of the basic engineering quantities among the various aircraft on which the typical ones are based. In particular, the specific fuel consumption of propeller-turbine engines varies widely; this will have an effect on the block fuel consumption and take-off weight of these aircraft, but the operating cost is not greatly affected, because the fuel cost is a comparatively small part of the total.

Figures relating to individual aircraft will be found to be better or worse than those of the typical hypothetical aircraft—our purpose being to show the general comparison between the two types of propulsion.

It is therefore believed that the comparison presented here (based on typical values) is perfectly objective and equally fair to both types, and that the operating-cost differences stated above are correct to within about plus or minus 5 per cent.

The very broadly equal direct operating costs are arrived at in spite of some substantial differences in the various items which make up the total cost, and these can be grouped together as follows:—

Fuel cost: At the high-speed cruising condition assumed, the jet fuel cost per unit of work done is nearly double that of the propeller-turbine at short ranges; on the longest stage, where the jet is cruised at a more economical speed, the difference is reduced to about 20 per cent.

Engine cost: The relative simplicity of the jet engine and the absence of a propeller result in its having a powerplant first cost and maintenance cost per unit of payload capacity which is only about 80 per cent of that of the propeller-turbine.

Airframe weight and cost: It appears that the airframe weight for a given payload is rather higher for the jet than for the propeller-turbine, the effect of the greater strength and stiffness required by the higher operating speed of the jet outweighing the longer undercarriage and larger tail areas necessitated by the latter's propellers and their destabilizing effects. There seems no reason, given equal production quantities in similar circumstances, why the airframe costs per pound of weight should differ significantly.

Speed: The obsolescence, insurance, maintenance and crew costs accrue on an hourly basis; and hence the higher speed, and consequently greater work capacity or productivity of the jet, give it an advantage over the propeller-turbine in the conversion from cost per hour to cost per ton-mile.

We have long been conscious of this latter quality of the jet. In an early Comet report written in 1945 the advantage of the jet relative to the piston engine was summed up in the following words:—

"Whilst the fuel cost and weight per ton-mile of payload is much higher in the jet than on the other, this is largely offset by the fact that the engines deliver at a great altitude a very high cruising thrust power in relation to their weight, cost, maintenance, drag, etc. The result of all this being that whilst the general characteristics of the aeroplane are fairly conventional, the speed is disproportionately high."

This remains broadly true of the present situation relative to the propeller-turbine.

Table 2 summarises the make-up of the percentage differences between the direct operating costs per ton mile of the jet and propeller-turbine. It shows that the more rapid increase in the cost of the jet as range decreases is due to fuel cost and to the fact that the difference in block speeds between jet and propeller-turbine decreases (the terminal time being a greater proportion of the block time).

TABLE 2

Excess of jet cost over propeller-turbine cost, as percentage of propeller-turbine cost.

Stage length (miles)	250	500	2,500
Due to fuel consumption	+23.1	+19.1	+6.1
Due to power unit cost	−6.2	−6.6	−5.4
Due to airframe weight and cost	+2.9	+3.1	+3.5
Due to block speed	−13.6	−17.7	−16.4
Due to higher take-off weight	+0.7	+0.5	+0.2
Net total	+6.9	−1.6	−12.0

The differences for the 2,500 mile stage are not comparable with those for the other stages, as the cruising speed of the jet has been reduced to 550 m.p.h. The adverse effect of fuel consumption now becomes comparatively unimportant and the difference in block speed gives the jet a considerable advantage in cost.

It is illuminating to note the effect on this comparison of the price movements which have taken place in the last 10 to 12 years. It is found that airframe and engine costs have risen much more sharply than fuel costs. As the operating cost of the jet is more sensitive to fuel cost than that of the propeller-turbine, and less sensitive to first cost, the movement of prices has been in favour of the jet. This partly explains why the jet is now more competitive, particularly on short stages, than it was just after the last war. It follows that the jet stands to improve its relative position if past trends continue in the future.

There is also the question of the operating cost method employed (the constants in any method are necessarily somewhat arbitrary), and to check this point the calculation for a 500 miles stage length has been repeated using the unmodified S.B.A.C. method, the A.T.A. method, and also the methods evolved by B.E.A. and B.O.A.C. to suit their own conditions.

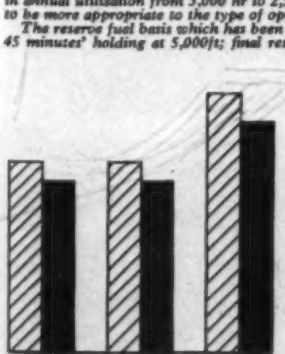
The relative cost of jet and propeller-turbine aircraft as displayed by these various methods is as follows:—

Method	Jet D.O.C. as percentage of propeller-turbine D.O.C.
Modified S.B.A.C.	98.4
Unmodified S.B.A.C.	100.3
A.T.A.	88.3
B.E.A.	95.7
B.O.A.C.	94.8

It is interesting to see that the relative situation is very

**The modifications consist of an increase in the depreciation rate from 80 per cent of the first cost in eight years to 90 per cent in seven years, and a reduction in annual utilisation from 3,000 hr to 2,500 hr; the modified figures are thought to be more appropriate to the type of operation under discussion.*

The reserve fuel basis which has been assumed is: 230 statute miles diversion; 45 minutes' holding at 5,000ft; final reserve (1,000 lb for the Comet 4B).



The "chimneys" on the left show at a glance the relative characteristics of jets and propeller-turbine transports as defined by the authors. Block depicts the propeller-turbine, shaded chimneys represent the jet.

The Comparative Economics of Jet and Propeller-Turbine Operations . . .

similar in all cases, except that based on the A.T.A. method where the low U.S. domestic fuel price favours the jet more than the propeller-turbine.

Tables 3, 4 and 5 present the comparison of the direct operating costs of the two aircraft in various ways, as follows:—

Table 3: costs in £ per hr tabulated under the headings conventionally used for such estimates; Table 4: costs in pence per ton mile tabulated under the same headings. (A comparison of Tables 3 and 4 shows the effect of block speed on cost.) Table 5: cost in pence per ton mile rearranged to show how much of the cost is due to each of the controlling factors.

Aerodrome Performance and Cruise Technique. It will be seen from Table 1 that the aerodrome lengths required by the jet for take-off and landing are greater than those of the propeller-turbine. In general it is true to say that runway lengths of this order are now or will soon be available where required. The jet is able to take advantage of these lengths and would, in fact, suffer an economic penalty if it had to be designed to lower take-off and landing distances. A jet designed specifically for short stages would have a better aerodrome performance at the same operating cost as the typical jet described in this paper. Alternatively it could show an improvement in operating cost for the same aerodrome performance as this typical jet.

The relative position of the jet in respect of aerodrome performance can if necessary be considerably improved by making use of the long-range cruising technique on the 2,500 miles stage. Calculations on this basis show that the jet's take-off aerodrome length is then reduced to 7,450ft, with a slight reduction in cost, while still retaining 100 m.p.h. advantage in block speed and 80 minutes' saving in block time.

Effect of Air Traffic Control Delays, etc. Protagonists of the propeller-turbine can no doubt show that the percentage increase in operating costs of the jet are greater than those of the propeller-turbine when both suffer an equal time delay. This is of course true; it is fundamental that the faster vehicle stands to lose a bigger fraction of its block speed in such circumstances.

However, in assessing the relative direct operating costs, it is the average cost of a large number of operations which is significant, rather than the cost of the occasional extreme delay. The costs which have been given are worked out on the basis of a 15-minute allowance for terminal time (including take-off and acceleration to climbing speed). If another ten minutes' stand-off were allowed on a 500 miles stage, the direct cost would be increased by about 12 per cent for the jet and 9 per cent for the propeller-turbine; that is, the comparison alters by only 3 per cent against the jet.

Profitability. A further point not displayed by the above comparison is the better utilization of capital resources by the jet. Since the work capacity of the jet is higher than that of the propeller-turbine due to its higher block speed, the number of jet aircraft required to meet a given traffic flow is less than the number of propeller-turbine aircraft of equal payload capacity, and the capital investment

TABLE 3
Cost in £ per flying hour.

Stage Length	250 st. miles		500 st. miles		2,500 st. miles	
Aircraft	Jet	Propeller-turbine	Jet	Propeller-turbine	Jet	Propeller-turbine
Cruise Procedure	Fast		Fast		Medium	Fast
Depreciation:						
Airframe and spares ...	54.1	49.7	54.1	49.7	54.1	49.7
Engines and spares ...	17.8	19.5	17.8	19.5	18.7	19.5
Propellers and spares ...	—	2.2	—	2.2	—	2.2
	71.9	71.4	71.9	71.4	72.8	71.4
Insurance	18.4	18.2	18.4	18.2	18.6	18.2
Maintenance and overhauls:						
Airframe	37.8	34.7	37.8	34.7	37.8	34.7
Engines	44.0	48.3	44.0	48.3	46.2	48.3
Propellers	—	8.6	—	8.6	—	8.6
	81.8	91.6	81.8	91.6	84.0	91.6
Fuel	181.9	76.9	172.0	73.5	122.5	76.7
Crew	7.5	7.5	7.5	7.5	7.5	7.5
Landing fee	25.6	18.0	16.6	10.7	5.5	3.2
Total (£/hr)	387.1	283.6	368.2	272.9	310.2	268.6

TABLE 4
Cost in pence per ton-mile.

Stage length	250 st. miles		500 st. miles		2,500 st. miles	
Aircraft	Jet	Propeller-turbine	Jet	Propeller-turbine	Jet	Propeller-turbine
Cruise procedure	Fast		Fast		Medium	Fast
Depreciation:						
Airframe and spares ...	2.93	3.44	2.36	2.97	2.01	2.42
Engines and spares ...	0.97	1.34	0.78	1.16	0.70	0.95
Propellers and spares ...	—	0.16	—	0.13	—	0.10
	3.90	4.94	3.14	4.26	2.71	3.47
Insurance	0.99	1.26	0.80	1.09	0.69	0.89
Maintenance and overhauls:						
Airframe	2.04	2.40	1.65	2.08	1.40	1.69
Engines	2.39	3.34	1.91	2.89	1.72	2.35
Propellers	—	0.60	—	0.52	—	0.42
	4.43	6.34	3.56	5.49	3.12	4.46
Fuel	9.85	5.31	7.51	4.40	4.54	3.74
Crew	0.42	0.52	0.33	0.45	0.27	0.36
Landing fee	1.38	1.24	0.72	0.64	0.18	0.16
Total (pence/ton-mile) ...	20.97	19.61	16.06	16.33	11.51	13.08

"Considerations such as those displayed in this paper," say the authors, "fortify de Havilland in their belief in the airliner which they pioneered in 1945." "Flight" photograph

Vanguard — the airliner which will epitomise the best in medium - turboprop economics.

The Comparative Economics of Jet and Propeller-Turbine Operations . . .

required is therefore smaller. Hence the jet fleet shows more favourable figures for the relationship of annual turnover and profit to capital investment. (It should be noted that, except for the B.E.A. method, the operating cost methods considered here do not include "Interest in capital investment" as a component of the direct operating cost). The comparative figures for the hypothetical aircraft considered herein are given in Table 6. (The revenue rates have been chosen arbitrarily but have been reduced, as stage length increases, in the normal manner.)

Conclusions. A study of existing and projected aircraft of both types indicates that their direct operating costs lie within a small percentage of one another over a stage length of 500 miles, the higher fuel cost of the jet being broadly offset by its lower power unit costs and high speed. At shorter stage lengths there is a small advantage to the propeller-turbine, while the jet improves its position as stage length increases and has a growing advantage above 500 miles. Furthermore, its higher speed results in a higher profitability and better utilization of capital resources.

There is thus seen to be a very good economic case for the application of the jet airliner over all stage lengths down to about 500 miles in Europe (and less under U.S. conditions). This might have some relevance to the observed fact that some constructors who only a short time ago were apparently wedded to the propeller-turbine seem now to be anxious to enter the jet field.

It is considerations such as those displayed in this paper which fortify the de Havilland Company in their belief in the jet airliner which they pioneered in 1945.

Acknowledgement: The authors wish to acknowledge the assistance of Mr. E. G. Wilkinson in the preparation of this paper.

Recent other articles and comments on jet v. turboprop economics have appeared in *Flight* as follows:

Brancker Memorial Lecture (Lord Douglas), February 15; *The Medium Jet Transport*, February 22; *The Medium Range Transport* (F. H. Robertson), March 8; *The Medium Transport Cost Controversy* (R. H. Whitby), April 5; *The Jet v. Turboprop Cost Controversy* (F. H. Robertson), April 26.

TABLE 5

Cost in pence per ton-mile.

Dependent on	Jet	Propeller-turbine	Difference P/T to jet percentage of total D.O.C.	Remarks
250 st. miles				
Fuel	9.85	5.31	+23.1	
Engine and propeller cost	3.53	5.72	−11.2	−6.2 per cent due to lower power unit cost/unit payload, −5.0 per cent due to speed.
Airframe weight and cost	5.79	6.82	−5.2	+2.9 per cent due to higher airframe weight/unit payload, −8.1 per cent due to speed.
Crew	0.42	0.52	−0.5	Due to higher speed.
Landing fee	1.38	1.24	+0.7	Reflecting higher fuel consumption and hence higher T.O.W. of jet.
Total	20.97	19.61	+6.9	
500 st. miles				
Fuel	7.51	4.40	+19.1	
Engine and propeller cost	2.84	4.95	−13.0	−6.6 per cent due to lower power unit cost/unit payload, −6.4 per cent due to speed.
Airframe weight and cost	4.66	5.89	−7.5	+3.1 per cent due to higher airframe weight/unit payload, −10.6 per cent due to speed.
Crew	0.33	0.45	−0.7	Due to higher speed.
Landing fee	0.72	0.64	+0.5	Reflecting higher fuel consumption and hence higher T.O.W. of jet.
Total	16.06	16.33	−1.6	
2,500 st. miles				
Fuel	4.54	3.74	+6.1	
Engine and propeller cost	2.54	4.04	−11.5	−5.4 per cent due to lower power unit cost/unit payload, −6.1 per cent due to speed.
Airframe weight and cost	3.98	4.78	−6.1	+3.5 per cent due to higher airframe weight/unit payload, −9.6 per cent due to speed.
Crew	0.27	0.36	−0.7	Due to higher speed.
Landing fee	0.18	0.16	+0.2	Reflecting higher fuel consumption and hence higher T.O.W. of jet.
Total	11.51	13.08	−12.0	

TABLE 6

Stage length	250 st. miles		500 st. miles		2,500 st. miles	
Aircraft	Jet	Propeller-turbine	Jet	Propeller-turbine	Jet	Propeller-turbine
Cruise procedure	Fast		Fast		Medium	Fast
Capital invested per aircraft (first cost plus spares) in £ ...	1,394,000	1,384,000	1,394,000	1,384,000	1,411,000	1,384,000
Work capacity at 85 per cent load factor (ton miles/annum)	7,200,000	5,640,000	8,910,000	6,520,000	10,510,000	7,990,000
Total operating cost assuming indirect cost at 21d./ton mile (£/annum)	1,935,000	1,470,000	2,116,000	1,559,000	2,190,000	1,742,000
Revenue (pence/ton mile) ...	70	70	65	65	55	55
Revenue at 65 per cent load factor (£/annum)	2,100,000	1,642,000	2,410,000	1,764,000	2,407,000	1,830,000
Profit (£/annum)	165,000	172,000	294,000	205,000	217,000	88,000
Turnover/annum (per cent) / Capital investment	151	119	173	128	171	132
Profit/annum (per cent) / Capital investment	11.8	12.4	21.0	14.8	15.4	6.4

The A.R.B.'s Year

Points from the 20th Annual Report

AT the annual luncheon of the Air Registration Board in London yesterday, Lord Brabazon, chairman of the Board, was due to present its 20th Annual Report (for the year ended March 31, 1957). We extract below some of the salient points.

Certificates of Airworthiness. There had been no certification of major types during the year, though the certification stage had been reached by the Twin Pioneer, the Auster B.8, and the E.P.9. With regard to the certification of foreign aircraft, the DC-7C had been required to comply with a "limited number" of British requirements additional to the U.S. requirements.

Ex-Military Aircraft. Lord Brabazon referred to statements in the aeronautical press indicating a "lack of appreciation in some quarters" of the Board's difficulties in the certification of ex-military aircraft. Considerations included the physical condition of the aircraft, and its modification and manufacturing standards. "The Board follows a reasonable policy in reaching *ad hoc* decisions on these matters, but the question of acceptance standards is by no means an easy one, and the Board is always ready to consider constructive proposals for changes of outlook or of method."

U.S.-U.K. Reciprocal Agreement. In 1952, the C.A.A. had notified the A.R.B. that pending development of U.S. requirements for turbine-engined transports, validation by the C.A.A. of British Cs. of A. would be dealt with by *ad hoc* examination of the type. This policy was applied to Capital's Viscounts.

The C.A.A. had now established a new procedure which extended the policy to ensure that aircraft were strictly in accordance with U.S. Civil Air Regulations. This procedure had, in the case of the Britannia, led to the imposition of additional "Special Conditions." Unfortunately, discussions with the C.A.A. had indicated that past agreements were in need of review. The C.A.A. had suggested that a comparison between certain sections of the current Civil Air Regulations and the British Civil Airworthiness Requirements should be made. "The Board hopes," said Lord Brabazon, "that this comparison will result in mutual acceptance of each country's code where the differences are relatively unimportant, leaving only a few Special Conditions covering the more significant conditions." Priority was being given to this work, and he was hopeful that it would be a major step towards obtaining "a more satisfactory arrangement between the two countries than that which exists at present."

Flight Testing. Unlike performance, handling matters affecting requirements could rarely be reduced to numbers, and they remained matters of opinion based on experience. New developments in speed, altitude and equipment suggested a need for greater A.R.B. participation in tests in order to ensure a constant level of interpretation of the requirements. Great responsibility in the A.R.B.'s flight test work devolved upon the Board's test pilots. Flying times had more than doubled during the past few years. "It is pleasing to record," he said, "that the Board's staff concerned with flight testing has, in gaining experience, won the confidence of constructors and has generally proved itself to be fit and able to control civil certification and testing." British constructors, not unnaturally, were reluctant to accept criticism and direction from any authority until they were satisfied that the authority was qualified and experienced. Lord Brabazon referred to the value, both to the constructor and the Board, of early participation in flight trials, and noted that, due to differing techniques or interpretation of the requirements, the Board's pilots were sometimes among the first to discover undesirable handling qualities.

Powerplant Development. The imminent use and potential future of British turbine engines in the U.S.A. had necessitated a great deal of discussion with the C.A.A. The intention of both A.R.B. and C.A.A. was similar, but requirements were often "at slight variance". Although all differences which could affect the sale of British engines had been discussed, "it appears judicious to work towards total elimination of such written differences as may exist".

Approval of Organizations. The Board's work in this field continued to grow, and for several years past the total number of "approved organizations", now 2,500, had increased by an average of approximately 200 each year.

Publications. Section C of British Civil Airworthiness Requirements (*Design Requirements for Engines*) "is now as up-to-date as any engine airworthiness requirement in the world, and is more comprehensive than any other". Section D (*Design Requirements for Aeroplanes*) was the most widely used in recommending Cs. of A. and thus its shortcomings were more frequently noticed. "In one or two items of importance the Section has fallen behind, and efforts are being made to remedy this." For instance work was proceeding with a general review of structural requirements relating to fatigue and the concept of "fail-safe" structures. On the performance side, the current requirements were recognized as being more modern than those in the printed requirements of other countries, but they were due for revision. Section G (*Design Requirements for Rotorcraft*) more than any other was in need of general revision, and it was felt that the present arrangement "could be too restrictive on the wide variety of rotorcraft types now being produced".

The publication of a handbook dealing with the choice and use of high-strength aluminium alloys in aircraft had been an important step. The co-operation shown by the S.B.A.C. had been a matter for satisfaction.

In the preparation of *Civil Aircraft Inspection Procedures* the A.R.B. had received considerable assistance from the A.I.D., which was "particularly gratifying".

Flight Manuals. The A.R.B. Flight Manual was a legal certificate, issued by the Ministry, containing prohibitions and limitations. This document therefore had to be compiled with considerable care and with attention to possible legal implications.

The development of the British Manual owed a great deal to the Americans who, of course, had introduced the concept. The manuals produced by the U.S. constructors (and approved by the C.A.A.), although open to criticism on several points, achieved an enviable standard which it had been the Board's constant aim to surpass. It was hoped that in the case of future new types, attention could be paid to operating procedures at an earlier stage in design.

Maintenance Schedules. An entirely new form of maintenance schedule, in which all parts of the systems were shown by perspective illustrations annotated with inspection/time requirements, had been prepared. This had worked well in practice.

Personnel Licensing. During 1956 an average of 43 pilots, two flight engineers and 17 maintenance engineers attended for written examinations each week. Aircrew examinations were held twice a week in London and at frequent intervals at London Airport.

The Board, with the agreement of the Ministry, had prepared four sets of general performance charts [see *Flight* for April 19, p. 529] to cover aeroplanes classified in Performance Groups A, C and D, and aeroplanes having no Performance Group.

Liaison with Overseas Authorities. Collaboration with officials of the C.A.A. had been "practically continuous", and representatives from Iceland, India, Israel, New Zealand and Southern Rhodesia had been studying the Board's activities.

Consultants. The Board was fortunate in being able to call on the services of Sir Alfred Pugsley, A. Cdre. A. H. Wheeler, and Professor A. J. Murphy.

Finance. There was a small surplus to carry forward for the year ended March 31. "I think it highly desirable," said Lord Brabazon, "to emphasize that the Board is a non-profit-distributing corporation, and that fees are not paid to council members for their services." If costs continued to rise, it might be necessary to make "further increases in the charges for the Board's services."

Council. Mr. F. E. N. St. Barbe, of de Havilland, had resigned from the Board after eight years' service in July, 1956. The vacancy had been filled by Mr. A. F. Burke, also of de Havilland. Ten Council meetings were held during the year, with average attendances of 14 members (total membership of the Council is 19)—"a worthy record when their honorary capacity is borne in mind."

Staff. "Bearing in mind the nature and extent of their duties, the fact that the staff enjoy extremely cordial, but nonetheless respected, relations with officials in operating and manufacturing organizations is in itself a commendation of their work." The Board had great confidence that under the leadership of the Chief Executive (Mr. R. E. Hardingham) and the Chief Technical Officer (Mr. W. Tye) the staff would maintain the high standards already achieved, and "retain the respect of all those with whom they come in contact." Lord Brabazon referred finally to the "excellent work" done in the sphere of overseas liaison by Mr. Tye and his deputy, Mr. Pardoe. Mr. Tye had "very successfully" led the airworthiness group at the Air Navigation Commission of I.C.A.O. in September 1956, and also took part in performance discussions with the C.A.A. in Washington. Mr. Pardoe headed an A.R.B. team which visited Seattle in February 1957, to appraise the design of the Boeing 707.

A pair of exotic Canadian ex-Service survey aircraft: top, a Boeing B-17 Fortress of the Photographic Survey Corp., operating in Baffinland; below, a D.H. Mosquito 35 of Spartan Air Services, Ltd., before leaving for Kenya.

AIRCRAFT INTELLIGENCE

U.S.A.

Boeing B-52. A major engineering change which will take effect from the 359th aircraft is a switch from pneumatic to hydraulic drives for the main alternators. Previously the latter were mounted in the fuselage and were driven through air turbines fed with bleed-air ducted from the engines. In the new system the alternators will be mechanically driven by the main engines operating through Sundstrand hydraulic variable-ratio drives.

Douglas Model 1906. The U.S. Navy are reported to be evaluating this projected four-turboprop high-wing STOL transport for use as an early-warning aircraft. The Navy have for some months been examining a development of the 1906 for operations as a carrier-based multi-purpose transport.

Lockheed CL-329. No doubt a derivative of the previously announced CL-135, the 329 is one of the light jet transport designs intended to meet U.S.A.F. requirements. Powered by four J83 or J85 engines mounted in side-by-side nacelles on the rear fuselage (or, alternatively, two Bristol Orpheus BOr.4), the 329 will carry ten passengers at from 500 to 550 m.p.h.

North American Sabreliner. Preliminary specification figures are now available for this projected transport (which is one of several entrants in the U.S.A.F. competition for a "combat-readiness" machine). Powered by four wing-root-mounted G.E. J85 turbojets, each of some 2,200 lb thrust, the Sabreliner is intended to seat nine passengers, take off after a 2,300ft run and cruise at Mach 0.76 at 39,000ft.

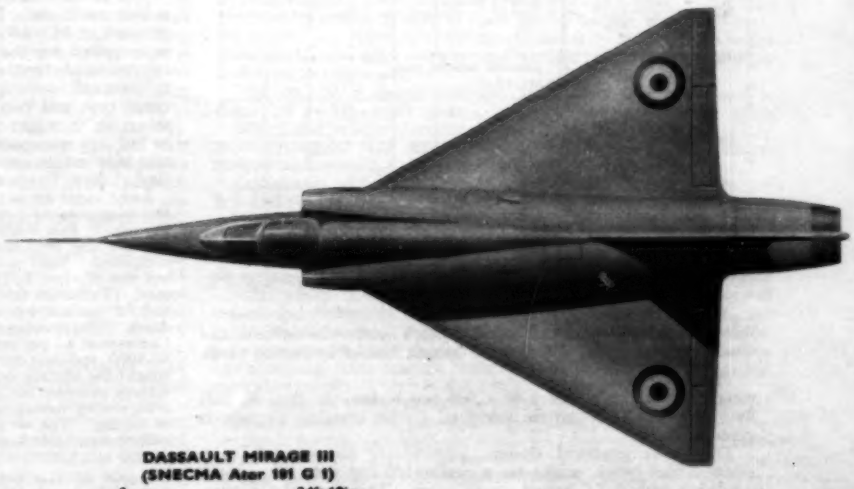
Republic F-105B. According to *Aviation Week*, present orders for this aircraft amount to only 175 examples—at a relatively low rate of production. In view of the outstanding performance of this machine such a decision seems surprising, particularly since the aircraft was planned as a multi-purpose weapon system for a number of roles. According to the American publication, it is likely that only the "simplest day version" will now be bought, possibly supplemented by a small number of tandem seat F-105Cs.

France

Nord 1500 *Griffon.* It is learnt that this canard delta has completed its first flight tests with the ramjet operating, in addition to the Atar turbojet. Speeds well in excess of Mach 1 have been achieved on the level, as well as supersonic stabilized climbs extending many thousands of feet. The Griffon is the first ramjet aircraft to achieve supersonic speed.

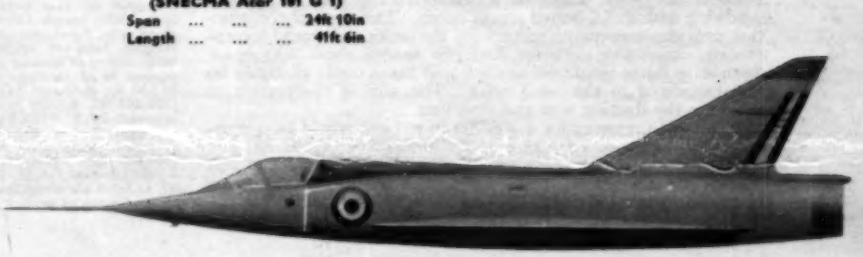
Sud Aviation S-58. The Sud Aviation plant at Marignane, now responsible for the assembly of the Sikorsky S-58, and later to undertake production, has assembled and flown the first of these American-licensed helicopters in France.

Sud S.E. 5003 Baroudeur. It is claimed that on the occasion of the Paris Show, the Baroudeur took off, on its skid undercarriage, in a distance of 679 yd and landed in 308 yd. In 18 seconds, at low altitude, it turned through 360 deg. This attack aircraft is to participate in the forthcoming NATO trials.



DASSAULT MIRAGE III
(SNECMA Atar 101 G 1)

Span	...	...	...	24ft 10in
Length	...	...	...	41ft 6in



Laminar-Flow Aircraft

New Projects Disclosed at Handley Page Symposium

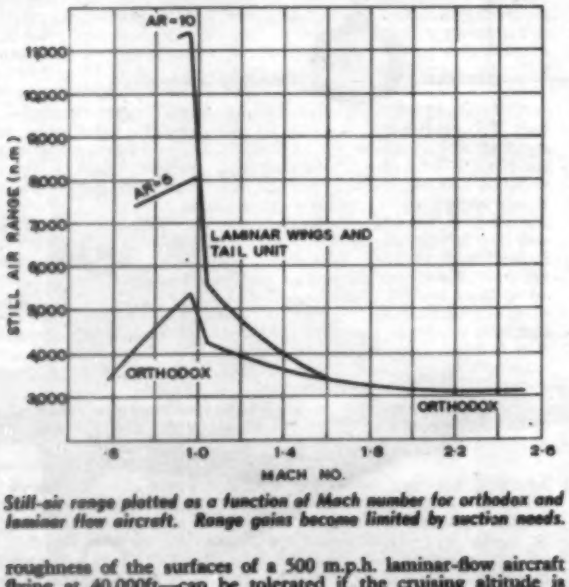
LAMINAR flow boundary layer experiments have been conducted since well before the war, but only recently has research advanced to a stage where practical specialized designs can be contemplated. In this country, boundary layer control has long been associated with the name of Handley Page, the firm that last week held a symposium to discuss the subject with the Ministries, airlines, A.R.B. and research establishments.

Five papers were read, reviewing the progress of research to date, explaining in detail the principles of suction-control of the boundary layer, examining the design techniques that have been developed and proposing specifications for aircraft that—by taking advantage of the lower drag conferred by laminar flow—would have trans-global range and cruising speeds of 500 kt.

There have been (it was explained) sufficient experiments carried out in this country and in America to show that in full-scale operating conditions wing profile drag can be reduced by suction to something like one-fifth of normal values. Although these results have been obtained on straight wings, recent theory suggested that similar benefits could be got from thin swept wings.

The state of the art at the moment, and the results of some years of development and research flying, were that full-chord laminar flow could be maintained up to Reynolds numbers in excess of 30×10^6; suction quantities for laminar flow (taking account of the power required) were sufficiently small for profile drag reductions of 70-80 per cent to be obtained; and it has been determined that increases of Mach number up to the critical value have no adverse effects upon the maintenance of laminar flow.

In parallel with this aerodynamic conquest, a great deal of patient research and experiment has been devoted to the special mechanical design features required to obtain laminar flow. A weight penalty of about $\frac{1}{2}$ lb per sq ft of "sucked" area is involved. Small surface irregularities—three or four thou.



Still-air range plotted as a function of Mach number for orthodox and laminar flow aircraft. Range gains become limited by suction needs.

roughness of the surfaces of a 500 m.p.h. laminar-flow aircraft flying at 40,000ft—can be tolerated if the cruising altitude is great enough.

The most practical design, particularly for aircraft with integral fuel tanks, might be a perforated top skin honeycomb sandwich with multi-bolted access doors. This type of construction provides very stable corners for the tanks and would accommodate chord-wise collector-duct ribs spaced about 10ft apart. Span-wise ducts would be needed, and these could probably be accommodated in the wing nose. The aim is everywhere to integrate the ducting with the structure.

Pump requirements for a 200,000 lb airliner would be a pressure ratio of about 2:1 and a power absorption of 300-400 h.p. each; they would be about two feet in diameter and two feet long. One suggestion is to house them in the engine centre body and have them clutch-connected to the power unit.

"Flight" copyright drawing

Artist's impression of one of the H.P. laminar-flow transports. It is designed to carry a 30,000-lb capacity payload 9,000 n.m. against a 30-kt headwind at M=0.85. The wing span is 200ft.

It was on the foregoing developments that Dr. G. V. Lachmann, director of research at Handley Page, was able to base his paper on "The design of aircraft with laminar boundary layer control." It was necessary, he said, that *ab initio* design should be applied to the integration of the wing and powerplant if the weight penalty was not to be excessive. Since wake drag on a "laminarized" wing is so very much less, structure weight, approach speed and cruise lift coefficient determine the wing size, and area need not be cut to the bone.

The chief advantage of boundary layer control aircraft was increased a.m.p.g., and their most obvious application the carriage of payloads over very long ranges. Although total efficiency increases with an increase in Mach number, lift-drag ratio decreases until "the shockingly poor lift-drag ratio of supersonic aircraft is of the same order as the stick and wire period," and it seemed doubtful if supersonic aircraft could ever be operated with reasonable economy over stages exceeding 3,000 miles unless nuclear-powered.

There were remarkable improvements in range to be gained by laminarization (continued Dr. Lachmann); the optimum regime occurred at cruising speeds of the order of M=0.85 to M=0.9, with some improvement at M=1.2, but fading out at M=1.5. The primary reason for the diminishing effect of induced laminar flow as Mach numbers rose was the increase of pump weight required to supply the necessary suction power. There was also a relative decrease in the drag reduction achievable at higher Mach numbers. Since there is a weight penalty (amounting to about three per cent of the gross weight), the laminar flow aircraft would carry slightly less fuel than a comparable conventional one; but because there was a drag saving of, say, 40 per cent this more than outweighed the loss of fuel, and the range improvement would be in the order of 60 per cent.

The laminar aircraft became more attractive as the stage length is increased: on a London - New York stage, carrying 30,000 lb payload at M=0.85 or 0.9, a gross weight of 200,000 lb would be required for the laminar-wing type against 300,000 lb for a conventional type. Three specifications for laminar wing and tail aircraft were proposed by Dr. Lachmann—a 4,500 mile range type and two types with still-air ranges of 12,000 n.m. or more which might meet the ultimate range requirement of civil or military transports. They could reach Australia from London non-stop while avoiding Eastern Europe, the Middle and Far East, Libya, Egypt and the Sudan.

Long range project "A" is designed to cruise at M=0.85. It is a low wing passenger transport with an aspect ratio of eight and 30 deg sweepback; four Rolls-Royce Conways are arranged in underslung pods and the flow over the wings, tail and Fowler flaps would be suction-controlled. Shaft power required for each pump would be 512 h.p., but the effective L/D ratio would be 40 including pump drag allowance. Turbulent flow is assumed in limited regions at the wing, tail, and fin tips and roots, on the fuselage and aft of the undercarriage leg doors. The cruising technique at 300,000 lb T.O. weight (running the Conways at 60 per cent of their maximum thrust) would be to climb to 40,300ft, and then drift up to maintain a L/D ratio of 39.4. At 180,000 lb weight the altitude would be 50,200ft. Project "B" is a more ambitious scheme designed for a still-air range of 13,600 miles at M=0.9. It is a high wing monoplane with an eight per cent wing and a sweepback of 42 deg. The very large span—220ft—is braced to keep deflections within reasonable limits; the L/D ratio is 42 and the cruising altitude 45,000 to 55,000ft.

Project A. Four Rolls-Royce Conway 10 of 16,320 lb thrust. Dimensions: Span 200ft; length 145ft; wing area 4,950 sq ft; aspect ratio 8; thickness/chord ratio, 7 per cent; dihedral, none. Baggage and cargo space, 1,000 cu ft. Weights: Take-off, 300,000 lb; wing loading, 60.6 lb/sq ft; landing, 200,000 lb; wing loading at landing weight, 40.4 lb/sq ft; payload, 30,000 lb for 9,000 n.m. against 30 kt headwind; total structure, 76,000 lb; total suction equipment, 10,500 lb; zero-fuel 167,200 lb. Performance: Take-off at sea level I.S.A. (300,000 lb), 6,150ft to 50ft; critical distance 7,300ft; cruise T.A.S., 486 kt; approach E.A.S., 115 kt; stalling E.A.S., 88 kt; D.O.C. 12.06d per short ton st.m.

Project B. Four Rolls-Royce Conway 10. Dimensions: Span, 220ft. Weights: Structure weight 24.7 per cent. Performance: Take-off at sea-level I.S.A. (300,000 lb), 6,000ft to 50ft. I.S.A. +15 deg, 7,350ft; critical distance, 6,500ft; cruise T.A.S., 515 kt; approach E.A.S., 110 kt; touch-down E.A.S., 97 kt; still-air stage length, 10,500 n.m.; D.O.C. 11.26d per short ton st.m. Other figures as project A.

No. 57 of the Series

SKEETER IN THE AIR

PLEASANT IMPRESSIONS OF SAUNDERS-ROE'S LIGHT A.O.P.-TRAINER

BY THE EDITOR

IT HAS been interesting to follow the fortunes of British-built helicopters during the last ten years; though we tend to forget it, the helicopter as a practical aircraft is not much more than a decade old. In some applications progress has been slow. No one would suggest that B.E.A.'s enterprising experiments of a few years ago have had a very exciting outcome so far. In fact, nowhere yet have passenger services by helicopter become truly significant.

In the Services, the picture is quite different, and no modern Air Force, Navy or Army can be considered well-equipped if it cannot call upon the varied, specialized services of helicopter squadrons. British forces are still under strength in this respect.

But regardless of which branches of helicopter operations are flourishing, there is clearly a need and a future for the Skeeter, in its rôle of trainer for all other types.

Saunders-Roe have had this Gipsy Major-powered two-seater under development since 1949, and in its latest marks—10, 11 and 12—it is an attractive and versatile little machine. A recent opportunity of learning more about it—in particular its flying qualities—was welcomed, and the experience proved a very pleasant one.

The particular aircraft flown was a Mk 6 demonstrator with civil registration. It had been made representative of the latest marks, except in power, which was in the region of only 195 b.h.p.

We chose a hot, humid day for our flights, proving pleasant for the pilots though a little trying for the Skeeter in some flight conditions. The later marks now in production have not less than 215 b.h.p., and they benefit considerably from the additional power in all operating extremes.

The Skeeter will be familiar to most readers, but some may wish to be reminded of one or two pertinent figures. The maximum all-up weight is 2,200/2,300 lb according to mark, the three-blade rotor diameter is 32ft, and the maximum cruising speed 88 kt. Best range and endurance figures of late marks are 185 n.m. and 3 hr. Current marks can better 1,000ft/min rate of climb.

Next to the clear bubbles of one or two foreign designs, the cockpit enclosure of the Skeeter provides almost perfect visibility. In a rearward direction, it is better than any other. We flew with the doors removed because of the heat, but this did not cause draughts. I am always relieved to have a good, strong lap-strap when sitting almost in open space; though whether hovering or cruising, there is no feeling of insecurity or vertigo. On the other hand, cliff edges, towers and similar heights off the ground make me feel distinctly odd.

The cockpit is simply laid out and though compact there is plenty of width—more than I had expected. Additional reach between the seat and rudder pedals, to allow a straighter leg position, would have been welcome. The passenger seat can be turned round for A.O.P. duties.

Compared with other designs, too, the Skeeter controls are few and simple. The full dual control system includes a separate left-hand collective pitch lever for each seat.

An unusual feature is the manual rotor clutch control which is mounted with the rotor brake and cartridge starter toggle, and so arranged that no misuse is likely to occur. Unless the rotor clutch (which is, in fact, a manual override lever for a normal centrifugal clutch) is pulled out in the disengaged position, the rotor brake cannot be held in the "on" position, nor can the cartridge starter be fired. This is because the clutch lever carries the retaining catch for the brake and, when engaged, covers the cartridge toggle. There is also a wheel brake lever.

All controls (other than the main flying ones) are grouped centrally between the instrument panel—topped by three warning lights for fuel pressure, generator and fire—and the aft central partition. They comprise no more than fuel booster pump switch, pitot heater, radio master switch, lights and ignition switches. Next, rearwards, comes the Plessey P.T.R.61 radio set in its mounting and (on the rear wall itself) a priming pump, a combined fuel and oil cock and night flare release buttons.

The instruments are familiar ones as seen in fixed wing aircraft, except for the combined engine and rotor r.p.m. dial which, however, is similar to that on other helicopters. A sign of the confident and experienced pilot is his ability to forget this dial and its green sectors, indicative of safe engine and rotor speed ranges for operation, and fly by ear and feel.

Rotor r.p.m. under normal conditions are about 330, but the

SKEETER IN THE AIR . . .

range permitted is quite wide. For cruising they should not fall below 300 or rise above 335. Normal maximum is 340 r.p.m., maximum overspeed, 345. Maximum continuous power is obtained at an engine speed of 2,500 r.p.m. with full throttle and 320 rotor r.p.m.

The collective pitch levers, with their fine-adjustment twist-grip throttles, have a sliding friction adjuster on the starboard side lever. The tall—overtall for me—cyclic pitch levers carry small electric trim switches which are pushed against light spring loading in the direction in which a trim change is desired. These levers also carry press-to-transmit buttons.

The rudder pedals, which, according to circumstances, must be used very sensitively or to their full extent, are perhaps a little primitive in design. The rudder is the most tricky control for the new pilot to master, and thus it should be as convenient in operation as possible. The use of the fine adjustment throttle is probably the next most difficult action, and this, too, should have just the right amount of smooth angular movement to cover the range of in-flight throttle changes with natural wrist flexion. On the Skeeter, the slightest twist produces a marked change in engine power (and thus in torque—to be countered by rudder movement).

Each time we prepared to take-off, the Gipsy Major fired first cartridge, and it was, I thought, an improvement to be able to run the engine at any speed desired without bringing in the rotor clutch until it was wanted.

When I first took over the Skeeter, not having handled a helicopter for some months, I was tense and clumsy with the controls, but—and this was important to me—I felt safe and had no fear that anything would get out of hand so long as the engine kept going. This was due, I believe, to the responsiveness of the controls, the good flying qualities of the Skeeter, and to the unusual stability of this little machine.

All control movements are small and precise; it is difficult at first not to lag on rudder correction, for anticipation rather than quick reaction is necessary. There is no shake or roughness about the cyclic stick, and the Skeeter answers to it naturally, more like a light fixed-wing type than any helicopter I have tried.

With careful trimming and setting, the hands can be taken off the controls and the Skeeter will hover into wind with rudder guidance alone. On this particular machine, on this hot day, and with full fuel load, 195 b.h.p. was only just enough and it was best to keep the rotor revs at the top of the green limit marking before moving off from the hovering position, or making power-using manœuvres such as pirouetting against torque. Once translational lift is helping, the Skeeter climbs away readily at its recommended speed of 45 kt.

Above and left, Suggestive of the A.O.P. rôle but, in fact, low-level [illegible]tures over the Skeeter cruises comfortably at 80 m.p.h. John Jeffries holds a steady [illegible] "Flight's" Geo[illegible]

The various transitions from climb to level, level to descent or into autorotation, are things that do not come smoothly and easily when a pilot is new to a helicopter. Even allowing for the fact that each additional flight brings an extra experience, I felt more capable and confident of flying and trying out the Skeeter, rather than guiding it gingerly, than any machine I had previously flown.

Clearly a good deal of trouble has been taken to get the right balance of power and pitch alteration which together follow movement of the collective pitch lever. This means that rev watchers like me do not worry and thus relax and fly better.

Turns are made as with any other aircraft. Take your club pilot and put him in the Skeeter at its easy cruising speed of 75 m.p.h. and he would fly it like a Tiger—though perhaps needing relatively more rudder when turning right against torque.

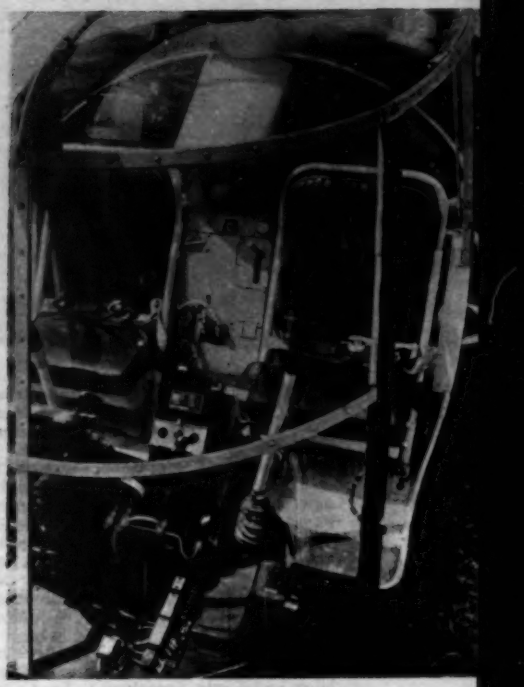
John Jeffries, the Saunders-Roe test pilot who demonstrated the Skeeter's performance to me, and is to be seen in some of the pictures, showed how confidently and smoothly the machine will about turn, dive and climb at low level, much as it had done during several Farnborough Show demonstrations.

One of the impressive points of handling is the controllability of the machine in full autorotation. Certainly you are coming downhill rapidly at 1,250ft/min, but direction can be controlled and there is some freedom of choice in emergency to alter forward speed in relation to rate of descent.

Minimum rate of descent is held at 25-30 kt forward speed, and the horizontal distance of glide seems to be about 350 yd per 1,000ft of height. With a forward speed of 50 kt, this distance can be stretched to perhaps 600 yd. Rotor r.p.m. in autorotation reach a maximum of 345.

Recovering from autorotation needs practice if it is to be smooth, and over-revving of engine and rotor is to be avoided. It is again a case of anticipation and quick, concise use of rudder is called for as power comes in. In autorotation, there is

...tures over the Solent foreshore near Calshot. The ... "Flight's" Gemini can move in close for photography.



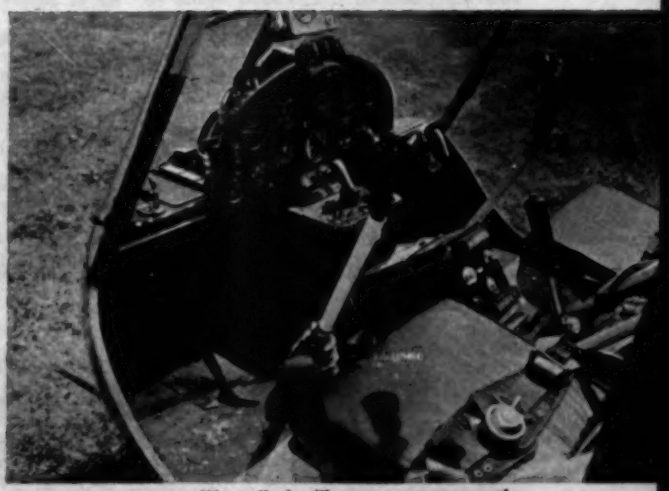
These views of the cockpit show the dual controls, central instrument panel and simplicity of layout. Note the ample width for comfort and freedom of movement.

negligible torque, and after a tail rotor failure the machine should descend without any particular change of direction.

In earlier articles on handling helicopters we have gone into the whys and wherefores, and described training and practice manœuvres. The Skeeter will, of course, taxi and do running take-offs, but we did not bother with such things on this occasion. The chief pleasure of the flights, and one of my main impressions of them, arose from the Skeeter's utility. For the first time, I felt that here was a machine sufficiently compact, simple, conventionally manœuvrable and comfortable to challenge the light fixed-wing machine on even terms. Of course it can offer a lot more in some respects, while on the other hand it is still considerably slower in cruising flight. But if the price can in time be brought within bounds, this is a type of aircraft I could use and appreciate week-by-week. Hitherto, like most other people, I have tended to regard rotorplanes as interesting experiments with some unique and important local applications.

In spite of its small size and the need to keep weight to a minimum, the Skeeter appears strong and durable; it offers adequate comfort, and there is nothing home-made or experimental about its finish. The cockpit is quiet in flight as helicopters go, and the days of vibration and shake seem happily to have passed.

The Skeeter can be equipped with a rocket booster system—the work of Napiers—which uses as fuel high test peroxide stored in a tank on top of the rotor hub. The booster system was not fitted to the aircraft when I flew it but the booster control panel is seen mounted above the instrument panel in a picture on the right. The blade tip boosters do not increase rotor speed but provide a great deal more lift and there is a very marked effect on performance. For example, sea level climb goes up from 1,020 to 1,800ft/min on this aircraft and the vertical rate of climb at sea level goes from 230ft/min to 1,100ft/min.



Wave flecks like a snowstorm on the return flight over Southampton Water.

In addition to about a dozen prototype and development aircraft—the earliest being built by the Cierva company—Saunders-Roe have production contracts to deliver various marks of Skeeter to the R.A.F., the British Army and the West German Air Force. The German order is for ten machines; the size of the British order may not be quoted.

Rising behind the high-speed-flow laboratory at Bedford is the distinctive vertical spinning tunnel. On the right of the laboratory is the 3ft supersonic-tunnel building.

R.A.E. BEDFORD

—and its Facilities: (I) the Wind-tunnel Site

"FLIGHT" PHOTOGRAPHS

THE official opening of the Royal Aircraft Establishment, Bedford (reported on page 4), marks an important stage in the story of postwar British research, a story which began in March 1944. After it had become evident that Farnborough had inadequate space for the new runway and wind-tunnel facilities which would be required, a firm recommendation for a new establishment was made at that time by the Aeronautical Research Council.

The A.R.C. report on this subject recommended the construction of the following facilities: a variety of wind-tunnels; a fully equipped airfield; workshops capable of major-modification work on aircraft and of serving the laboratories and tunnels; and a power supply with a peak load capacity of about 200,000 h.p.

In the autumn of 1944 a site north of Bedford was chosen; this embraced the three wartime airfields at Twinwood, Thurleigh and Little Staughton. Trial borings had shown that the subsoil foundations were suitable for the construction of the heavily loaded foundations of the proposed wind-tunnel installations; power supplies up to 150,000 Kw were available from Little Barford power station, nine miles east-north-east of Bedford; and water supplies up to 400,000 gal daily could be obtained by adaptation of an existing Air Ministry pumping station on the river Ouse within three miles of the site. At a later date Bedford Corporation would be able to supply the ultimate requirements of 750,000 gal per day.

The Government's decision to proceed with the construction of the new establishment on the Bedford site was announced by Sir Stafford Cripps (Minister of Aircraft Production) in the House of Commons in February 1945. A team of scientists and engineers from the M.A.P. and M.o.W. was formed and, in April 1945, visited the U.S.A. to study American research equipment and techniques before beginning the design of the Bedford facilities.

By mid-1946 plans for both the wind-tunnel site (adjacent to Twinwood) and the airfield (at Thurleigh) were well advanced, and at the end of 1949 most of the roadways had been completed and work had begun on the 3ft supersonic tunnel. Three years later this tunnel was in operation, testing models of new designs such as the P.1, and a good deal of work had been done on the construction of the main runway.

Further tunnels have since been constructed, notably the recently completed 8ft supersonic facility—the most powerful and complex wind-tunnel in the country. The Naval Air Department and the Flight Division of the Aerodynamics Department of R.A.E. moved from Farnborough to Bedford Airfield in 1955, and the Blind Landing Experimental Unit joined them from Martlesham Heath this year.

A first description of the Bedford tunnels (the establishment was then known as the National Aeronautical Establishment) was given in *Flight* for February 25, 1955. In the present article the facilities of the wind-tunnel site are reviewed and the 8ft tunnel is described in detail; next week's issue will contain an illustrated account of the facilities and work of the airfield units, including the Flight Division of the Aerodynamics Department, and the Naval Air Department.

Low-speed problems are investigated at Bedford in the **13ft×9ft tunnel**, which is used both for fundamental research (e.g. into the characteristics of various wing planforms) and for *ad hoc* work on specific aircraft designs. Maximum airspeed is 300 ft/sec.

The tunnel circuit is of conventional rectangular planform, and in it the air is circulated by a 30ft-diameter fan driven by a 1,500 h.p. motor fitted with automatic speed control. To ensure a smooth airflow there is a large settling chamber, giving a contraction ratio of 16:1, which is fitted with fine-gauge screens.

Aerodynamic forces on the models, up to a maximum of 5,000 lb lift, are measured by means of a six-component overhead balance. Auxiliary compressors and evacuators can provide pressure or suction on models for boundary-layer control or jet-flap experiments, and variable-frequency generators are available to power propellers or ducted fans mounted in models.

The **3ft×3ft** tunnel was originally designed as a supersonic installation, but a ventilated working-section was later provided for transonic testing. For some time this was the only tunnel of its size in the country available for supersonic or transonic testing, and investigations into aircraft designs have constituted a large part of its work. More recently larger tunnels have become available and so more general and fundamental research can be carried out in the 3ft tunnel.

In order to have the tunnel in use as soon as possible, it was decided to use compressors and driving machinery taken from Germany after the end of the war. The equipment was installed exactly as it had been at Volkenrode, but a new aerodynamic circuit was designed to make the best use of the available airflow and pressure-ratio.

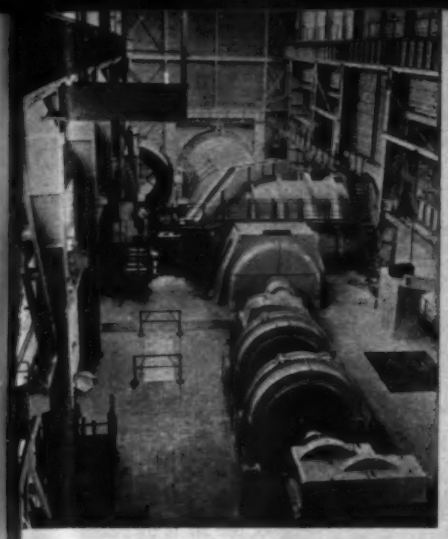
The 3ft facility is designed for operation up to M=2. Stagnation pressure is variable from 0.1 to 2 atmospheres absolute, but at the upper end of the speed range the operating pressure is limited by the 16,000 h.p. available from the main drive. The supersonic nozzle is asymmetric, being shaped on the top wall only, and Mach number is changed by changing this contour. Nine interchangeable liners are utilized.

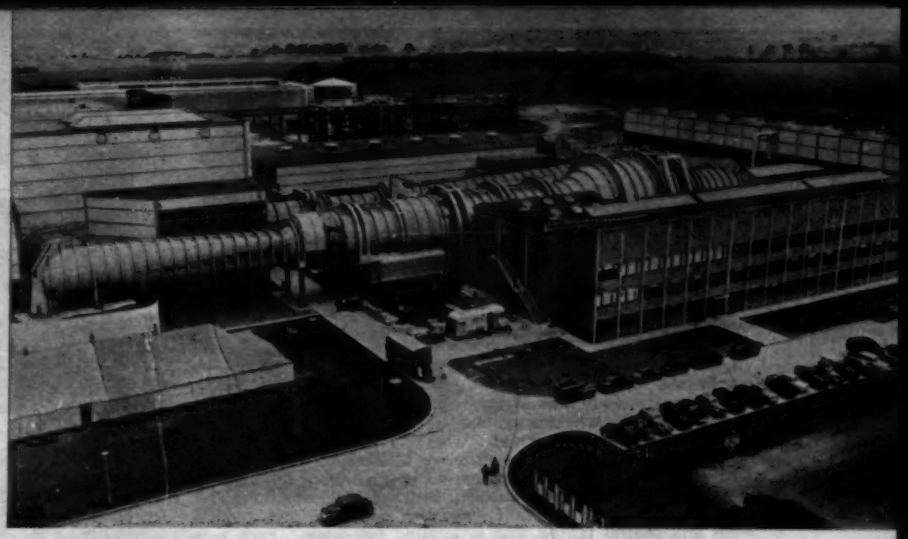
In addition to the supersonic working section, there is a transonic working section with slotted walls. Each working section is mounted on a trolley and the two are readily interchangeable.

The models, which vary in length from 1½ft to 2½ft, are normally sting-mounted, measurements of forces and moments being carried out with interior resistance-straingauge balances. For certain applications a half-model can be used.

Upstream of the working section is a large settling chamber giving a contraction ratio of about 35:1, in which are located fine-gauge screens for smoothing the airflow. The complete tunnel circuit includes two large centrifugal compressors connected in series, with inter-coolers and after-coolers which limit the work-

With the exception of the wooden working section and the steel fan section, the entire circuit of the 13ft by 9ft low-speed tunnel is constructed of concrete.





The massive 8ft supersonic tunnel (right) is driven by a 68,000 h.p. A.C. motor and two 6,000 h.p. D.C. motors (left). Behind the office block is the large-diameter cooler section; to the left of the block is the removable supersonic diffuser section. In the interior view showing the main drive to the tunnel, the six-stage high-pressure section of the compressor has been moved to the left and replaced by a plain section.

ing stagnation temperature to about 40 deg C. The stagnation pressure is adjusted by means of auxiliary compressor evacuators, and an air drier ensures that the humidity in the tunnel circuit is low enough to avoid flow disturbances caused by condensation when the air is expanded in the supersonic nozzle.

Newest, biggest and most complex of the Bedford R.A.E. supersonic installations—and indeed of all wind-tunnels existing in this country—is the **8ft × 8ft tunnel**. This impressive facility, which operates at Mach numbers up to 2.8 (excluding the transonic range), is designed both for fundamental research and for tests on models of complete aircraft and missiles. The working section is large enough for accurate representation of details such as control surfaces on complete models, and air density can be varied so that the maximum Reynolds number consistent with model strength or available power can be obtained at all speeds. The stagnation pressure can be varied from 0.1 to 4 atmospheres absolute, and the working section region of the tunnel is enclosed in an outer pressure shell.

The nozzle for generating supersonic flow in the working section incorporates top and bottom walls made of flexible steel plates. These are supported on a number of hydraulically operated screw jacks which can be adjusted to provide a continuous control of supersonic Mach number. The uniformity of the airflow in the working section depends critically on the shape of the nozzle walls, and an elaborate control system is used to set the jacks accurately to the required positions.

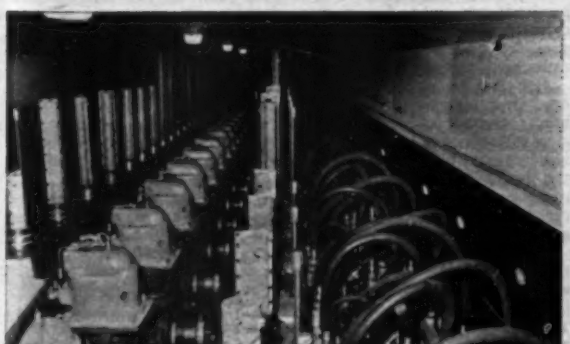
The advantages of this type of adjustable nozzle are that time is saved which would otherwise be spent in changing nozzle blocks to obtain different Mach numbers, and that a high standard of flow uniformity is possible by re-adjusting the nozzle shapes if necessary.

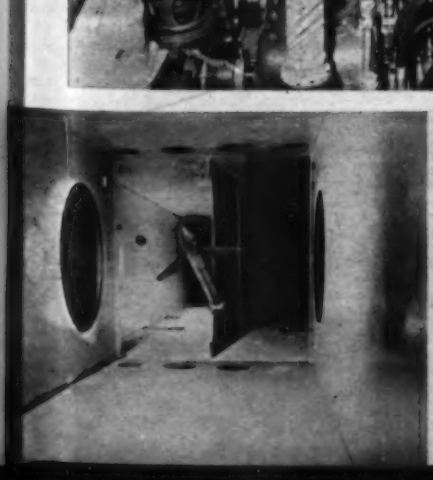
Downstream of the working section is a supersonic diffuser which is also adjustable in order to improve the efficiency of pressure recovery; while upstream is a large settling chamber giving a contraction ratio of 16:1 and incorporating fine-gauge screens for reducing turbulence. The working section can be by-passed by bleeding air from the settling chamber and returning it to the main circuit through injector slots in the diffuser. This by-pass is used to match the compressor characteristics at high Mach numbers while at the same time improving the performance of the diffuser.

The air is circulated by a 10-stage axial flow compressor which is built in two parts, enabling the six high-pressure stages to be moved out of position and replaced by a plain section, leaving four stages in the circuit. This improves compressor efficiency at the lower pressure ratios required for Mach numbers up to 1.6. The compressor is driven by electric motors totalling 80,000 h.p., and there is a 53,000 h.p. gas-turbine generator station which permits considerable flexibility in the driving procedures.

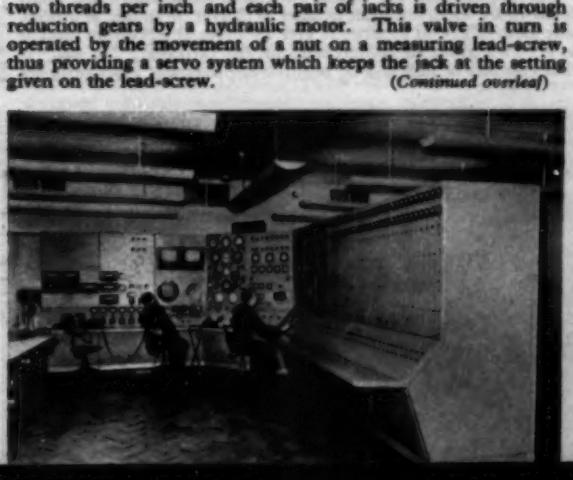
The temperature of the air at the compressor outlet may reach 160 deg C and there is provision for the free expansion of the tunnel shell on its supports. A large cooler before the settling chamber reduces the stagnation temperature to 40 deg C and is designed to give a uniform temperature distribution over its outlet area. The auxiliary plant associated with the tunnel includes compressors and evacuators to provide the required stagnation pressure in the tunnel, and air driers to maintain the lowest possible humidity.

Details of construction.—The working section is built up of two flexible top and bottom plates which are 8ft wide, 1in thick and 64ft 8in long, supported between two side walls 8ft 6in high and 62ft 6in long. The side walls are each fabricated as box girders and are connected by portal frames, making a rigid structure weighing about 400 tons. The flexible plates are made of Ducol steel and each consists of two pieces butt-welded together to give the required length. On the back of each plate are welded 30 transverse T-stiffeners to each of which are attached a pair of hydraulic jacks. The jack-screws are 3½in in diameter with two threads per inch and each pair of jacks is driven through reduction gears by a hydraulic motor. This valve in turn is operated by the movement of a nut on a measuring lead-screw, thus providing a servo system which keeps the jack at the setting given on the lead-screw. *(Continued overleaf)*





(Left) Working-section view of the 8ft tunnel, showing sting-mounted model and divided supersonic diffuser. (Right) Part of the observation room. (Above) Control units for shaping the tunnel's top flexible wall.



R.A.E. BEDFORD . . .

The lead-screw settings, and hence the shape of the nozzle, are controlled by a digital information system in the form of a number of punched telegraph tapes, one for each jacking station. These tapes are fed simultaneously through tape readers, the lead-screw setting being changed by 0.0025in (or in some cases 0.00125in) for each hole in the tape. In this way the nozzle shape can be changed continuously, the profile can be accurately controlled, and the required Mach-number setting can be obtained by stopping the tape at the appropriate point.

The maximum jack movement, at the throat position, is just under 3ft, and the complete range of movement of 14,000 steps would take about 40 minutes.

The supersonic diffuser is divided into two channels by a central fairing 15in thick which is used to support the sting on which the model under test is mounted. The model with its sting may weigh up to one ton, and the diameter of the sting root is about 7in. The sting support can be moved in pitch (±23 deg) and in roll ±180 deg) by servo-controlled hydraulic motors.

This diffuser is some 60ft long with fixed top and bottom walls and central fairing, and articulated side-walls. Each side wall is built up of four straight sections, connected by hinges and moved by hydraulic jacks. At the third hinge an adjustable injector-slot is provided, also operated hydraulically.

The main tunnel shell is built on a centre-line in the form of a rectangle 350ft by 60ft, and the cross-section diameter varies from 20ft at the compressor outlet to 47ft at the cooler. The steel shell is of welded construction with plate thicknesses of ¾in to 1¼in. At each corner of the circuit a cascade of turning vanes is fitted, consisting of 15 bent one-inch plates.

The cooler, which is integral with the shell of the settling chamber, consists of 58,000 horizontal steel tubes, 1½in in diameter and 16ft 6in long, expanded and welded into end-plates 47ft in diameter and 2½in thick. The tubes also pass through three baffle plates, giving four vertical water passes. The cooler is designed for an airflow through the tubes of 1,200 lb/sec, a temperature reduction from 160 deg to 50 deg C, and a water flow of 1¼ million gallons per hour.

The shell surrounding the working section and supersonic diffuser is 30ft in diameter, and access is obtained through an elliptical opening (9ft 6in×7ft 6in) sealed by a hydraulically operated door. The whole of the diffuser section of the shell is mounted on a trolley so that it can be moved out of position.

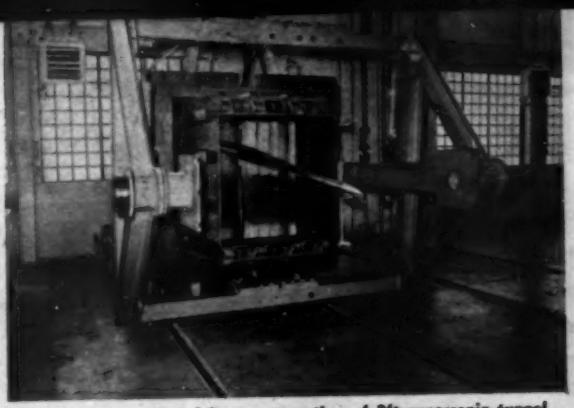
The tunnel structure weighs about 5,000 tons and is supported on massive concrete foundations. The cooler, compressor and the two smaller corners are fixed rigidly to the foundations, and the remainder of the structure is supported in such a way as to allow thermal expansion.

The main compressor is a ten-stage axial flow unit with a maximum airflow of 50,000 cu ft/sec. The maximum speed of the compressor is 750 r.p.m. The unit is made up of a fixed four-stage low-pressure section and a movable six-stage high-pressure section. This latter section is mounted on a truck so that it can be moved out from the tunnel and replaced by a dummy section (with an annular air passage) for certain aerodynamic conditions. The compressor absorbs an input of 80,000 h.p., but is designed for an ultimate power input of 100,000 h.p.

The compressor is driven by a composite main drive comprising a 68,000 h.p. synchronous motor and two D.C. motors, each of 6,000 h.p., connected in series. The D.C. motors are coupled to the 68,000 h.p. motor through a helical gear box.

The three methods of driving the main compressor are (1) by the two D.C. motors alone, with automatic or manual speed control; (2) by the two D.C. motors together with the 68,000 h.p. A.C. motor supplied at 50 c/s from the C.E.A. grid to give a constant-speed drive at 750 r.p.m.; and (3) by the two D.C. motors together with the A.C. motor supplied from the gas-turbine alternator sets giving a variable frequency of 10 to 50 c/s with consequent speed range of 150 to 750 r.p.m.

For pressurizing the tunnel two three-stage centrifugal compressors are used, either in parallel to deliver 36 lb/sec at a pressure ratio of 2:1 or in series to give 23 lb/sec at a pressure ratio of 4:1. Two trimming compressors are also provided. For evacuation two sets of helical-lobe positive-displacement evacuators are used, which together can evacuate the tunnel to 1/10 atmosphere in eleven minutes.



Trolley-mounted model-support section of 3ft supersonic tunnel.

All air admitted to the tunnel is dried, partly by cooling, partly by means of refrigerated brine and partly by silica gel absorbers. While the tunnel is running the dryness of the air is maintained by circulating a small flow of dried air in and out of the circuit by means of a trimming compressor and an evacuator—an arrangement which also allows a precise control of tunnel pressure. A battery of eleven induced-draught cooling-towers is used to dissipate the heat from the various coolers in the plant.

Now under construction at Bedford is the **4ft×3ft supersonic tunnel**, broadly similar in function to the 8ft tunnel but with a speed range from Mach 2.5 to 5. This is believed to represent the upper limit of speed for a conventional continuous-flow supersonic tunnel.

Stagnation pressure in this tunnel will vary from five atmospheres at M=2.5 to 14 atmospheres at M=5. The supersonic nozzle will be adjusted by moving the top and bottom walls, which are flexible over the greater part of their length and controlled by electrically operated jacks.

The **vertical spinning tunnel**, seen in the heading picture on page 18, was fully described (with cutaway drawing) in our issue of February 25, 1955. The purpose of this tunnel, which has a 15ft diameter working-section, is to investigate spinning characteristics of aircraft by means of free-flying dynamic models in an upward airstream.

The 4,000 h.p. compressor of the spinning tunnel is also used to supply air to the **high-speed-flow laboratory**. This comprises four test bays, in which various tunnels can be installed. One typical tunnel has a 9in×8in working-section with nozzles for Mach numbers up to 3, and has been used for heat-transfer tests.

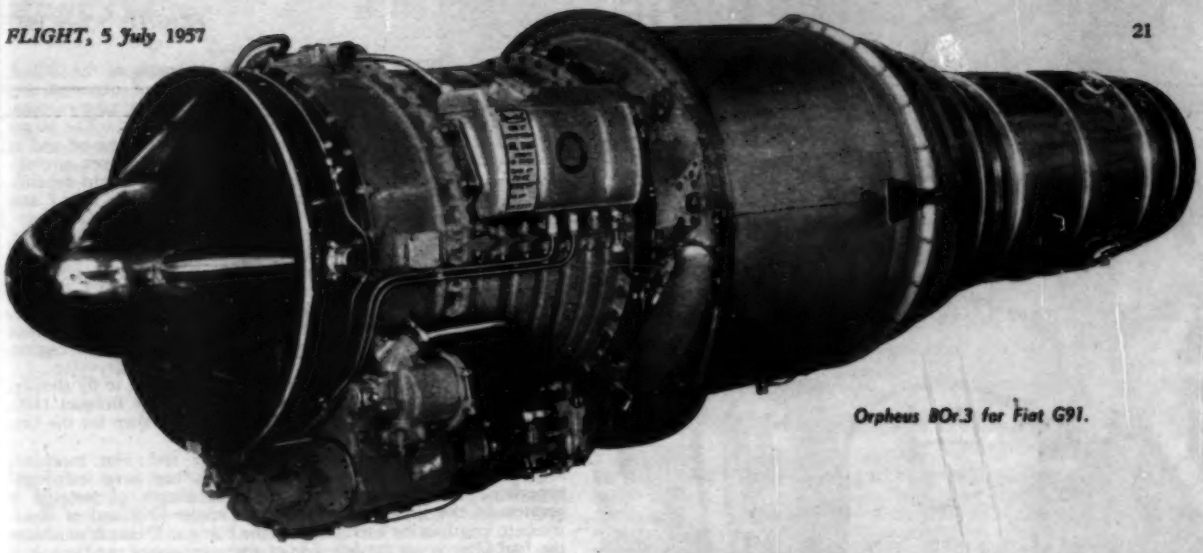
Instrumentation and data handling are important aspects of the work in all tunnels at Bedford. For force measurements on models, internal straingauge balances are generally used, measuring 3-6 components of force and moment by means of resistance straingauges. For measurement of pressure various methods are used: liquid manometers with automatic probes; capsule manometers incorporating automatic weighbeams; and pressure transducers consisting of a diaphragm coupled to an unbonded straingauge.

For the recording and subsequent analysis of test results, equipment is provided by which force and pressure measurements are automatically punched on cards. The readings are also immediately available to the operator. The punched cards are later fed into an electronic digital computer which produces the final results either as printed tables or plotted curves. This computer is also used for other purposes such as numerical calculations in theoretical aerodynamics, and in connection with the machining of aerofoil surfaces in the workshops.

The Bedford facilities are the impressive result of collaboration on a large scale between engineers, designers and research scientists from both industry and government departments. No fewer than 700 companies were involved in the design, construction and installation of the various buildings, equipment and plant; some of the major contractors and their contributions are listed on page 26.

(The second part of this account of the facilities at R.A.E. Bedford will appear next week and will describe the airfield equipment and operating units.)

Views of the low-speed tunnel: (left) a delta model in the 13ft×9ft working-section, with tuft net and camera behind the model; and (right) the 31ft diameter fan section.



Orpheus BOr.3 for Fiat G91.

PROGRESS WITH THE ORPHEUS

BRISTOL'S LIGHTWEIGHT TURBOJET ADVANCES TO HIGHER POWERS

THE completion last month by the Orpheus BOr.3 of its Official Type Test at the design rating of 4,850 lb thrust represents a remarkable achievement. The design of the engine was started in December 1953 and the first Orpheus ran on December 17, 1954. The fact that only two and a half years elapsed between the first run and the completion of the Official Type Test at the design thrust emphasizes not only the soundness of the development programme, but also the dependable nature of the original design. In fact, not since the Derwent and Nene—whose development was in the hands of the present chief engineer of Bristol Aero-Engines, Dr. S. G. Hooker—has an engine been designed and developed so rapidly. Incidentally, it is pertinent to note that the Orpheus is in a sense a replacement for these centrifugal engines, being in the same thrust class though of much lighter weight.

The thrust/weight ratio of the Orpheus BOr.3 is 5.99 lb thrust per lb-weight, undoubtedly the highest figure recorded for any type-tested turbojet engine in the world.

As is often the case with successful engines, the demand for increased operational performance has caused the aircraft designer to ask for still more thrust. The development of the Orpheus is therefore already proceeding beyond the original design figure. The Orpheus BOr.3 was developed under Ministry of Supply contract for the joint Mutual Weapons Development Programme, as a result of agreements between the United States and the United Kingdom. The Mutual Weapons Development Programme is the agency charged with the administration of United States funds for the purpose of assisting the development and production of defence equipment for the NATO countries.

Besides the 5,760 lb Orpheus BOr.11 announced in March, Bristol Aero-Engines are also developing, under the auspices of the MWDP, an advanced version of the engine designated BOr.12, for which the design thrust is 6,810 lb dry, a figure which can be boosted to nearly 8,000 lb by the use of reheat. This engine is primarily intended for lightweight strike aircraft to meet the requirements of SHAPE.

Since the basic design of the BOr.12 is the same as that of earlier Orpheus engines, it will be appreciated that the increase of weight over the figure of 810 lb applicable to the BOr.3 will be relatively small. The resulting thrust/weight ratio will therefore be altogether exceptional.

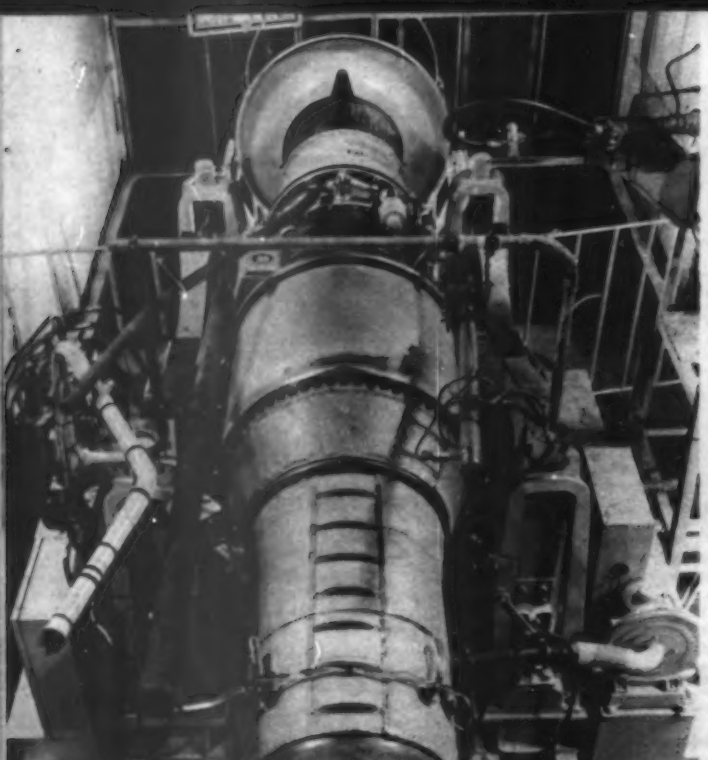
The use of the Orpheus engine in European light fighters has resulted in considerable interest from Continental engine manufacturers, and it was strongly rumoured during the Paris Show that a licence agreement had actually been signed between the French national aero-engine concern, SNECMA, and Bristol for the manufacture of the engine in France. No confirmation of this suggestion has been issued; but, on the other hand, it has not been denied. Moreover, in Italy, Fiat of Turin have an agreement for technical collaboration with Bristol, which includes an option to manufacture the Orpheus in that country.

As is well known, the Orpheus is also the powerplant of the Folland Gnat, which is to be built at the parent factory at Hamble, as well as in India, and Finland, as a result of the adoption of the Gnat for the air forces of those countries. In India the Gnat will be built by Hindustan Aircraft, Ltd., at Bangalore, and the Orpheus will also be built under licence at Bangalore in accordance with an agreement signed between the Indian Government and Bristol Aero-Engines in September last.

In a brochure issued at the Paris Show by North American Aviation, the Orpheus is specified for the NAA-249 jet trainer as an alternative to the Westinghouse J34. This aircraft is envisaged for training pilots through various stages, from primary to advanced, and may well be widely adopted where economical training is required. A two-seater, it has a design gross weight of 9,500 lb and a maximum speed of 495 m.p.h. with the 3,400 lb-thrust J34. A substantial number of these aircraft have already been ordered by the U.S. Navy as the T2J-1, and although these aircraft may be powered with the J34 further orders are expected to follow. Proposals are to be made by N.A.A. to the Royal Canadian Air Force concerning the Orpheus-powered version, and the company has also approached the U.S. Air Force. The latter has inspected the mock-up of the aircraft at North American's Columbus, Ohio, Division.

It has also been reported from foreign sources that the Lockheed Aircraft Corporation are interested in a version of the Orpheus to power a prototype twin-engine jet utility transport (the GL-135, by the California Division); and, indeed, the Orpheus is likely to have an important future in this field. A special derated version, known as BOr.4, has been developed from the BOr.3 especially for trainers, transports and executive aircraft. This version will have a low specific fuel consumption and an extended life between overhauls, as a result of the reduction of both the turbine operating temperature and the compressor r.p.m. The BOr.4 is rated at 4,230 lb. One class of trainer for which this engine is likely to be widely adopted is the two-seater developed from the corresponding fighter or strike aircraft, and an example of this is the transonic Fiat G91-T, a tandem two-seater developed from the G91 lightweight strike machine. The G91-T can be used for advanced training, and it can also take off from short, semi-prepared strips or grass fields, and would therefore make an ideal trainer for pilots scheduled for posting to lightweight strike squadrons. The G91-T has evidently been designed with this requirement very much in mind.

The Orpheus was originally planned, as a private venture, for lightweight fighters and similar aircraft. Detail design, which began in December 1953, was given a flying start by the numerous calculations and design studies which had already been made on this class of engine. The first aircraft for which the Orpheus was chosen was the Folland Gnat; and, as the very similar Midge was already flying with a different powerplant, there was a natural desire to bring the Orpheus to the flight stage as soon as possible. All the detail drawings were issued within six months, and the manufacturing simplicity built into the design was such that an engine was assembled and run by December 17, 1954. Compressor rig tests were carried out before and during the running



The Orpheus BOr.3 after successful completion of the full 150-hr type test early in May. Above the compressor is the cartridge starter.

PROGRESS WITH THE ORPHEUS . . .

of the engine. Although the first engine was run with a six-stage compressor, the rig tests showed that seven stages were entirely practical. The second and subsequent engines therefore incorporated the additional stage.

In order to clear engines for flight in the Gnat, an Orpheus BOr.1 was submitted for an official 150-hour type-test, at the relatively low rating of 3,285 lb-thrust, within five months of the first run. This type-test was successfully completed on May 6, 1955, and an engine was despatched to Folland Aircraft the following month. The Gnat made its first flight on July 18 in the hands of S/L. E. A. Tennant, Folland chief test pilot. The handling of the Orpheus received considerable praise, particularly for its rapid acceleration.

Meanwhile, early in 1956, the BOr.1 was type-tested at its design rating of 4,050 lb. By April 1956, when over one hundred flights had been made by the Gnat, an Orpheus BOr.2 was installed in an underwing pod on Bristol's Avro Ashton flying test bed in order to supplement the engine performance measurements. The BOr.2 is the standard engine for the Gnat.

In August of the same year, the first flight of the Fiat G91 lightweight tactical fighter took place at Casella Torinese near Turin. The G91 was the first to fly of the three lightweight strike aircraft ordered for evaluation by SHAPE, the other two being the Dassault Etendard VI and the Bréguet 1001 Taon. These aircraft were built to a specification issued by SHAPE, the philosophy behind which was concerned with the provision of large numbers of light and mobile aircraft for the support of ground troops in Europe. The requirement envisaged that these aircraft would have a first-class flight performance at low altitudes but with limited range and armament, and that they would avoid destruction on the ground through exceptional mobility which would be ensured by operating from grass fields and semi-prepared strips. In this way immense concrete aerodromes would be rendered unnecessary and the reduced need for fuel, ammunition and spares would simplify the logistics problem.

The Orpheus BOr.2, for the Folland Gnat, was type-tested at its full rating of 4,520 lb in November 1956. Here it is convenient to mention how the various Marks of Orpheus differ from one another. The BOr.2 is almost identical with the BOr.1 except for aerodynamic improvements which give it the higher take-off thrust. The BOr.3 is aerodynamically the same as the BOr.2, but has a larger wheelcase carrying a fuel pump of increased size, and increased-capacity accessories which were particular requirements of the European lightweight strike machines. The larger fuel pump gives the BOr.3 an increased thrust at take-off and at low altitudes, to meet the specialized needs of support aircraft; above heights of the order of 10,000 feet (the exact height depending on forward speed) the thrusts delivered by the BOr.2 and BOr.3 are identical.

By the end of February 1957 the BOr.3 was cleared for flight, and engines of this type were delivered to Générale Aéronautique Marcel Dassault at Saint-Cloud, near Paris, and to Fiat SpA at Turin, for installation respectively in the Etendard VI and the G91. The Etendard VI flew for the first time on March 15, although Marcel Dassault had already obtained flight experience with the earlier Etendard IV powered by the larger Atar engine, and the Etendard II with twin Turboméca Gabizos.

The Orpheus-powered Bréguet 1001 Taon is due to fly shortly, though an essentially similar aircraft known as the Bréguet 1100, and powered by two Turboméca Gabizos, was flown for the first time on March 31 at Istres.

Powerplants for the Dassault, Bréguet and Fiat machines are all basically similar BOr.3 units, but they have individual superficial distinguishing features. The length of jet-pipe is greatest in the Bréguet 1001, shortest in the G91 and of intermediate length in the Etendard. On the Fiat and Dassault machines the fuel filter is on the left side of the compressor, whereas it is directly below the engine on the Bréguet. The Fiat engine has a single hydraulic pump on the rear face of the port side of the wheelcase, supplied with the powerplant; for the French aircraft the Orpheus are delivered without such units and the airframe firms add twin hydraulic pumps on the front and rear faces of the same wheelcase. A particular feature of the Etendard units is that they are run into the fuselage on small rollers carried on brackets on the compressor casing.

The prospect of using afterburning in advanced versions of the Orpheus has already been mentioned, and this feature is most likely to find application in transonic or supersonic military machines. The Orpheus has already been run with Bristol Simplified Reheat,* the degree of thrust augmentation in this case being approximately 15 per cent.

A development which has civil as well as military applications, however, is thrust reversal; a thrust reversal system has already been tested on the Orpheus and has been successfully operated up to a reverse thrust of 1,500 lb. This would undoubtedly give a considerable braking effect, and would enable the ground roll on landing to be substantially reduced while avoiding undue wear and tear on the tyres and brakes of the aircraft. Orpheus thrust-reverse is now almost fully developed.

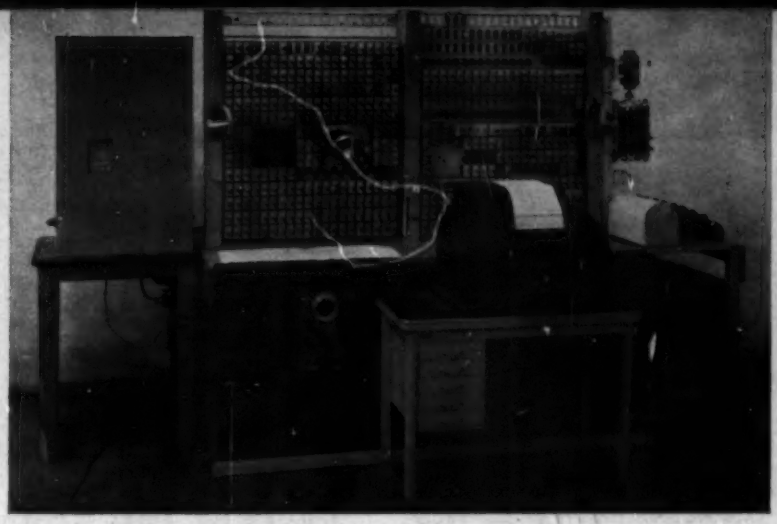
An unusual application for a jet engine is as a thrust booster for heavily-loaded piston-engined transports, examples of this being the application of small turbojets to such twin-engined machines as the Packet, Provider and Noratlas. The Orpheus, by reason of its excellent thrust/weight ratio and relatively low specific fuel consumption, would be eminently suitable for boosting a large aircraft in this manner.

Another application made possible by the excellent thrust/weight ratio is for the provision of vertical thrust in high-speed VTOL aircraft. In this application the engines might be pivoted; alternatively the lift-engines would be used only for take-off and initial climb and the final stages of descent and landing, while horizontally-mounted turbojets would be used for normal flight.

The Orpheus has already been selected for a number of very advanced projects in various countries; those which may be revealed include the Aerfer Leone, a mixed-power interceptor designed by Ing. Stefanuti in Italy; the Hispano HA-300, designed under the direction of Professor Willi Messerschmitt in Spain; and the Japanese Fuji TIF-1 trainer.

**Bristol Simplified Reheat, or B.S.R.: a neat and rudimentary form of afterburning in which fuel is injected from behind the engine tailcone, used in conjunction with a fixed-area propelling nozzle.*

Watching the type-test are Mr. J. H. Dale, Orpheus chief development engineer, and Dr. S. G. Hooker, director and chief engineer.



Laboratory model of the SATCO computer. On the right is the magnetic memory drum for storing flight plans. Flight data displayed on the central panel can be transferred to an adjacent centre by pushing a selection button. Printed circuits are widely used.

SATCO

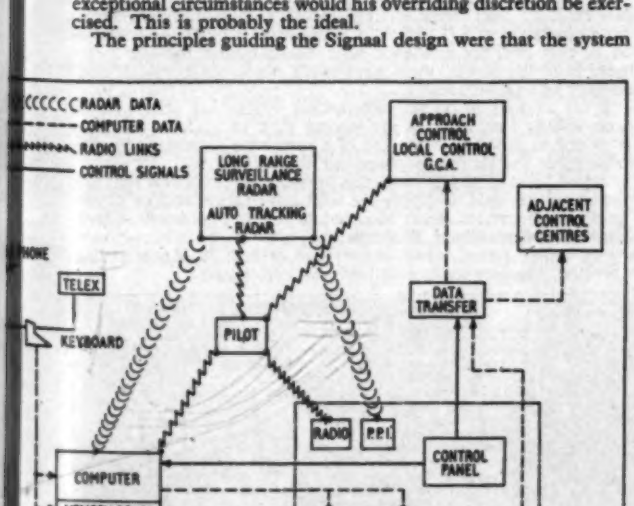
An Automatic Air Traffic Control Computer from Holland

NO subject has been more thoroughly debated, or its shortcomings ventilated, in the past twelve months than that of air traffic control. If conclusions have been reached, they are that the problem is multi-sided, and that no one solution will meet it. Great pains have been taken to show that the facile "You gotta problem? Buy a radar" is not the panacea for A.T.C.'s ills that at face value it might seem to be. Useful though it is, radar still leaves unsolved many problems of speeding traffic flow and of long-range separation.

One bottleneck which remains to be eliminated is the manner in which—at peak periods—controllers may be forced by sheer weight of numbers to delay the traffic under their control. The need for help from some form of automatic computer that can ease the controller's workload becomes obvious. In particular, the method of handling aircraft by means of the flight progress strips which contain details of the aircraft's flight plan and the position calculations of the controller is outdated and must soon be replaced.

Now being developed in Holland is a computer system which—by eliminating much of the controller's clerical work and mental arithmetic—may go far towards solving airways and terminal area bottlenecks. Called SATCO—Signaal Automatic Air Traffic Control—it is the first major venture into the civil field by Hollandse Signaalapparaten of Hengelo, Holland. At present only a concept and a laboratory model, the system merits close study since, in conjunction with automatic radar equipment and an aircraft data link (the development of Tacan is an example), it could in developed form present the air traffic controller with the information, the time and the opportunity to act solely as the monitor of an automatic air traffic control system. Little voice communication with the aircraft would be needed and only in exceptional circumstances would his overriding discretion be exercised. This is probably the ideal.

The principles guiding the Signaal design were that the system (1) should not require any major change in existing flying or air traffic control procedures; (2) could be used without additional special equipment in aircraft or in adjacent air traffic control centres; (3) in the event of emergencies could be overruled at any time by the controllers; (4) should be able to deal with all types of aircraft; (5) should be adaptable to particular control centres and airports; (6) should be gradually introduced into the present system, building up eventually to an integrated, fully automatic one; and (7) should at all times be guaranteed to "fail-safe."



The basic air traffic computing element of SATCO can be combined with airfield and surveillance radar, data link with aircraft and communication equipment to form the integrated system shown in this block diagram.

The SATCO system starts its operation either when a pilot's flight plan is filed or when a telex message is received from the departure airfield. For *en route* control, the input information may come from the radar to which the system is coupled, a telephone message from an adjacent A.T.C.C. or a position report from the aircraft.

Initial flight data is fed into the system either by manual teleprinter or by the automatic data transfer equipment over the telex lines; but it is not brought into operation until positive information is obtained of the entry of the aircraft into the system or of the aircraft's readiness to take off. When this information is received the controller inserts a "correction" to the original flight plan or departure message. This insertion activates the system and causes the computer to make its calculations. It then calculates the expected time of arrival of the aircraft at the reporting positions along its route, checks this flight path against the flight paths of other aircraft already in the system, discovers whether there is a conflict or not and, if there is, calculates a flight path for the aircraft which will be free of conflicts and which will be as near to the original flight plan as possible.

The results of these calculations (which are computed within two seconds) are displayed to the controller both on a "tote" type of display—showing the call-sign, type, height, etc. of the aircraft—and on the dynamic "clear-view" P.P.I. display which shows the position of the aircraft in three dimensions. Each aircraft under control is identified by special symbols. At the same time the data is printed out automatically on a form of progress strip which is intended as a legal record for filing rather than for operational use.

The progress of the aircraft through the system is subsequently checked either by position reports from the aircraft itself, or by radar. In the case of position reports from the aircraft the controller must insert the corrections manually into the system which will then recalculate and, if necessary, correct the clearances. In the case of radar corrections, the data is fed automatically into the system, which again will correct the clearances and warn the controller of any changes that may have to be made. The automatic functioning of the radar system is achieved by the use of special long-range 10 cm tracking radars linked with SGR 200 25 cm surveillance radar. The former is to have automatic "lock-on" devices to check a sequence of tracks, and an initial detection range of up to 180 miles. The long-range surveillance equipment, fitted with variable-speed Moving Target Indication to reduce weather clutter, would have a discrimination of up to 200 miles. Provision is also made for the automatic input of data derived from airborne navigation equipment.

Transfer of control of the aircraft—for inbound aircraft to the approach control of its destination, for outbound or overflying aircraft to the adjacent control centre—is carried out by a simple push-button process on the tote display panel. This interrogates

SATCO . . .

the memory of the system and automatically dispatches the extracted information over the telex network in code, so that even if the adjacent centre or airport is not fitted with SATCO equipment it can still receive the data on a normal teleprinter. The aircraft is not cleared from the system until positive information is received that it has either landed or that it is under control by the adjacent centre.

The system is intended to be operated in three development stages. The basic stage is the automatic processing of flight planning data and to this may be added—either alternatively or together—automatic radar and automatic communication equipment. Normal radar and communications can be used at the expense of a fully automatic system. Further, the system can be used merely as an automatic flight path calculator, as a calculator with automatic data transfer along telex landlines, or as the full system which involves automatic traffic planning and clearance calculations with ground-to-air and air-to-ground data links. Coarse advanced planning can be stored in the memory drum up to twelve hours ahead of the movement.

The best use of the clearance function, the manufacturers suggest, involves an artificial block system of separation based upon distance. Blocks 3½ miles long, 500ft high and as wide as the airway or flight path in use are proposed, with one block separation under SATCO control in V.F.R., two blocks with radar control and four without. The computer would then select the shortest flight paths where the number of blocks for the required separation would not conflict.

It would be incautious to assume that the laboratory model of the SATCO system is the immediate answer to the controller's prayer. At the moment, only three aircraft types can be catered for on the laboratory model display, and considerable testing will be required before controllers are convinced that an electronic brain—in spite of duplication, triplication and self-checking—will always fail safe. Some manufacturing problems remain to be solved, and the proposed block separation system may not be universally acceptable. The data link and automatic radar features of the system have yet to be developed and—although systems exist—the ultimate success of SATCO may depend upon the ease with which it can be integrated into traffic control developments elsewhere, when it goes into production in 1960. This may be a job for I.C.A.O., or for the I.A.T.A. technical committee (the latter have already, say Hollandse Signaalapparaten, expressed interest in the system). The outcome will probably depend upon the full-scale pre-production trials of SATCO which are to be undertaken at Schiphol.

CORRESPONDENCE

The Editor of "Flight" is not necessarily in agreement with the views expressed by correspondents in these columns; the names and addresses of the writers, not for publication in detail, must in all cases accompany letters.

Too Many Aircraft for B.O.A.C.?

I READ your estimate (June 7, page 784) that B.O.A.C. have ordered 70 per cent too much equipment for their likely traffic needs in 1965. I think many people must have been wondering what the Corporation intend to do with all the aircraft now on order or in service. But can they, as their intended order for 35 VC-10s suggests, really be planning on wiping their boards clean of Comet 4s, Britannia 102s and 312s and Seven Seas?

The Seven Seas and Britannia 102s may have paid for themselves by 1963, when the VC-10 deliveries start, but the Comet 4s and Britannia 312s will certainly not have done so. It may be logical to dispose of the Comets (if a secondhand market can be found), because the VC-10 is its logical replacement; but the disposal of Britannia 312s would mean the virtual abandonment of British long-range turboprop operations, and of all the benefits these aircraft might bring in low-cost transatlantic travel.

It is the *size* of the VC-10 order (35 aircraft) that is so staggering. While it may seem fair to conclude, as you do, that "B.O.A.C. must be planning on an all-jet fleet of 707s and VC-10s," I hope you are not right.

London, W.2. DRAUGHTSMAN.

Mr. Dorman and Croydon

IN the Croydon Chamber of Commerce meeting report (*Flight*, June 21) you say I recalled that the hangars are the oldest aeronautical buildings in the world; to which you added the editorial comment, "not so."

Not so to you, Sir! Your reporter quoted me inaccurately. I said Croydon airport buildings and hangars are the oldest *civil aviation* buildings in the world, which I think *is* so. Probably the oldest aeronautical building is the balloon shed at Farnborough which I saw there at cadet camps in 1910.

With regard to a decision having been taken to close Croydon next year (to which you add "as indeed it has"), four days after the meeting the M.T.C.A. told me the Minister had only said he *expected* Croydon to be closed and available for sale about 1959. So what?

London, S.W.5. GEOFFREY DORMAN.

[Quite so. The White Paper on London's Airports presented by the Minister of Civil Aviation in July 1953 made it clear that when Gatwick was developed "Croydon will be sold and will become available for other purposes." Answering a question in the House in February 23, 1955, the Minister gave 1959, when Gatwick was completed, as the date anticipated for closing Croydon. Operations at Gatwick should start in April next year, and the M.T.C.A.—in implementing this policy—have intimated in letters to Croydon operators that flying will therefore cease next year.—Ed.]

Honeycomb Production

OUR attention has been drawn to a note which appeared in your issue dated June 7 under the heading "Avro Honeycomb."

In this it is stated that Mr. J. A. R. Kay, Avro director and general manager, said "Avro are the largest producers of honeycomb core in Europe, and the great strides made in its development puts the company in a strong position to corner the world's markets in this particular field. It may also give British industry its biggest boost for years." It is also stated that a recently developed machine is able to produce 1,200 sq ft of core per hour.

In this connection, it may interest your readers to learn that this company is one of the largest manufacturers of honeycomb in the world. Before accepting Mr. Kay's claim that Avro are the largest producers of honeycomb core in Europe, we would require evidence in justification thereof.

"Dufaylite" honeycombs are not only manufactured in the United Kingdom by us and two licensee companies but also produced in ten European countries. The total output of these enterprises may be estimated if you take into account that one worker is capable of producing 1,800 sq ft of honeycomb per hour. Our methods of production are, of course, fully covered by international patents.

J. H. GORELL,
Managing Director, Dufaylite Developments, Ltd.,
Borehamwood, Herts.

"Bert" Hinkler—Information Wanted

MAY I, through your columns, appeal to any of your readers who can supply me with factual information concerning the late H. J. L. (Bert) Hinkler, 1892-1933? I am gathering material for a biography of S/L. Hinkler, who, through his flying activities in Britain and his residence near Southampton for the major portion of his career, must have made numerous contacts, both socially and professionally.

I am anxious to obtain information which may otherwise be irretrievably lost, for it is my sincere wish to make as complete a record as possible of the life of a man who so materially contributed to the air link between our countries.

Should you kindly publish this appeal, may I request that any reader who is able to supply me with information and/or photographs may contact me at Mooroondu Road, Thorneside, Cleveland Line, Queensland, Australia.

R. D. MACKENZIE.

FORTHCOMING EVENTS

July 5. Tiger Club: Aerobatic Contest, Sywell.
July 5-8. Swiss Aero Club: International Rally, Bienne.
July 6-7. Aéro-Club de l'Ouest: International Rally, Angers.
July 6-8. Invitation Rally, Deauville.
July 9-14. Pescara Aero Club: International Air Week.
July 10. Kronfeld Club: Film Show.
July 12-13. Royal Aero Club: National Air Races, King's Cup, and Lockheed Aerobatic Trophy, Baginton.
July 14. Northamptonshire Aero Club: At Home.
July 14. Wolverhampton Aero Club: Invitation Rally.
July 14. Yorkshire Aeroplane Club: At Home, Sherburn-in-Elmet.
July 17. Kronfeld Club: "Meteorology for the National Championships," by Wally Wallington.
July 18-20. R.Ae.S., British Interplanetary Society, College of Aeronautics Symposium, Cranfield.
July 20-21. Bornholm Flying Club: International Rally, Denmark.
July 21. Derby Aero Club: At Home.
July 26. R.N.A.S. Culdrose, Cornwall: At Home.
Aug. 5-10. Institute of the Aeronautical Sciences: National Naval Aviation Meeting, San Diego, Cal.
Sept. 2-8. S.B.A.C. Show, Farnborough.

Left, two Tiger Moths of the Surrey Flying Club en route to Flers for the tenth rally of the Lower Normandy Aero Club. Above, the scene at Flers aerodrome, with a Stampe in the foreground and a Minicab overhead.

CLUB AND GLIDING NEWS

A TOTAL of 65 aircraft participated in the tenth international rally organized by the Lower Normandy Aero Club at Flers last month. They included 35 from the U.K., of which 23 were from the Surrey Flying Club. It therefore came as no surprise when Surrey were awarded the Claude Salle Trophy for the club with most machines present. The presentation (illustrated below) was made at a luncheon at Bagnoles. Among those who attended the rally were Monsieur C. Harel, president of the Federation Aeronautique de l'Union Française; M. Leportier, mayor of Flers; l'Abbé Amiard of the Flers club, Mr. G. H. M. Miles, chairman of the A.B.A.C., and Sir Alfred Le Maitre, of the M.T.C.A.

YEADON Aero Club's At Home on June 23 attracted visitors from Sherburn, Newcastle and Rearsby. The afternoon's main contest was a bombing competition between Yorkshire Aeroplane Club and Yeadon Aero Club for the "Mailed Fist" Trophy. Yeadon managed to retain this for a further year by a chased, following an increase in A.T.C. scholarship flying, and 23ft and 24ft. Prizewinners included Capt. Leetham, Auster Alpha (sealed arrival time); B. Barker of Yeadon (individual bombing competition); R. Parker of Yeadon (spot-landing contest); and J. Harris Reed of Newcastle, Tipsy Trainer (smallest aircraft travelling longest distance). The prizes were presented by Mrs. Lawrence Dawson, wife of the chairman of Yeadon Aviation, Ltd.

OVER 2,500 hours were flown during the first five months of 1957 by Fair Oaks Aero Club, whose Open Day will be held on Saturday, July 13. This occasion will be a joint operation by the Fair Oaks club, the Vickers-Armstrongs club and the London Transport club. One of the Fair Oaks members is Maj. Maunde-Thompson, who recently attained his 80th birthday—still holding a current P.P.L.—and who celebrated with a Chipmunk flight.

A MARKED increase in the number of Transvaal flying clubs was reported recently by the chairman of the Letaba Flying Club, which now operates from a field near Tzaneen. Support for the clubs is strong from the farming community, who helped by providing 30 tractors and 500 men to clear the Letaba Club's site, previously covered with dense bush. The South African Ministry of Transport, it is reported, has been asked to increase the annual subsidy to the clubs from £22,000 to £45,000.

LANCASHIRE Aero Club completed 1,520 flying hours during the twelve months ending May 31, 1957, and their target for the coming year is 1,800 hr. A second Tiger Moth is being purchased, followed an increase in A.T.C. scholarship flying, and plans are being made to hire a Magister on a temporary basis. Recent events at Barton include a visit by B.B.C. cameramen for the television programme "Panorama"; and a "South Seas Dance Night" at which a free buffet was provided at 5s per head (we quote from the club's recent newsletter).

ANNUAL report of the Kuala Lumpur Flying Club for 1956, recently published, describes "a quiet year but, nevertheless, a successful one." A total of 860 hours was flown and 35 licences were gained. Included in the flying hours total is an amount of aerial photography and "pay drop" work which brings in a useful revenue for the club. Last year's events reviewed in the report include the successful All-Malayan Air Rally, which was held in Kuala Lumpur and which coincided with the club's silver jubilee. Officers of the club include V. Arunasalem, president; R. L. Akers, vice-president; A. E. Nichol, club captain; F/L. W. F. Eurke, club vice-captain; and D. W. A. Blye, hon. secretary.

WINNER of a recent aerobatic contest organized by the Royal Aero Club of New South Wales at Camden, south of Sydney, was Dr. Dorothy Rutherford, flying a Tiger Moth. Second and third places went to Mr. R. White and Mr. R. Green.

THE ninth Air Tour of Sicily was won last month by Robert Goemans of Belgium, flying a Piper Apache. Carina Negrone of Italy (Piaggio 136) was second and Hendrik Burgerthout of the Netherlands (Bonanza 435) was third.

NOW taking place at Pont St. Vincent are this year's French National Gliding Championships, in which eighteen pilots are flying Bréguet 901 sailplanes. These pilots were chosen by a selection committee, and from their performance the new French single-seater champion will be determined. Also taking part, in the international class, are other French and foreign pilots, including Dr. Brennig James of Britain. The Wassmar Javelot, Bréguet 902 and Bréguet 904 will also be flown in the championships, which began on June 30 and will end on July 13. The eighteen selected pilots are each designated "amateur" or "professional."

Personalities at the Flers rally: (left) Mr. G. H. M. Miles presents the Claude Salle Trophy to Peter Chinn of the Surrey Flying Club, with M. Herel of the F.A.U.F. looking on; (centre) Father Dubois, Father Amiard, Mrs. Sproxton, and Surrey C.F.I. Alan Sproxton; (right) a group of Surrey members, Alec Bray, David Housden, William Hipperson, John Donovan and Miss Frankie O'Kane.

Four new directors of Vickers-Armstrongs (Aircraft), Ltd., whose appointment to the Board is referred to below. From left to right, Mr. H. H. Gardner (chief engineer, military aircraft); Mr. A. W. E. Houghton; Mr. B. Stephenson (chief engineer, civil aircraft); and Mr. S. P. Woodley.

THE INDUSTRY

Vickers Appointments

FOUR appointments to the Board of Vickers-Armstrongs (Aircraft), Ltd., have recently been announced. Messrs. H. H. Gardner (chief engineer, military aircraft); A. W. E. Houghton; B. Stephenson (chief engineer, civil aircraft); and S. P. Woodley become directors, and the company has also announced a number of other appointments, two of them affecting Mr. Houghton and Mr. Woodley.

Mr. Houghton (formerly assistant general manager, experimental and production) is made general manager, Weybridge and Hurn; Mr. Woodley (formerly superintendent, Supermarine Works) becomes general manager, Supermarine Works. Mr. Allen H. C. Greenwood (formerly assistant general manager, service) becomes deputy general manager, Weybridge and Hurn; and Mr. R. Edmonds (formerly manager, works administration) is made assistant to the general manager, Weybridge and Hurn.

Mr. A. W. E. ("Charlie") Houghton started work with Vickers when he was 15 as a junior fitter at the Weybridge works. No apprentice scheme as known today existed then, but in 1927 he qualified as an aircraft master fitter and remained in the fitting shop until 1932. He was then transferred to the experimental department, being appointed a supervisor in 1933 and in 1938 entering the main production shops, where he became foreman in charge of wing assembly. In 1940 he was appointed senior foreman in charge of the experimental department responsible for the building of prototype aircraft under the department management of Mr. (now Sir) George Edwards. Two years later he was appointed assistant manager of the experimental department, becoming manager in 1946. In 1953 Mr. Houghton was appointed assistant general manager responsible for all experimental projects both at Weybridge and Supermarine, and in 1955 he became a special director of the company and was given full responsibility for the production programmes of all Vickers aircraft.

Mr. Woodley started his apprenticeship with Supermarine in 1927, later working for various aircraft companies but returning to Supermarine in 1937. At the beginning of the war he moved to the shadow factory at West Bromwich, becoming planning manager and assistant general manager. Mr. Woodley was made superintendent of the Supermarine Works in 1950 and a special director of Vickers-Armstrongs (Aircraft) in 1951.

The appointments of Mr. Gardner as chief engineer, military aircraft, and of Mr. Stephenson as chief engineer, civil aircraft were referred to in *Flight* for January 25.

Bedford Contributors

OF about 700 companies whose work went into the design and construction of the wind-tunnel and other facilities at R.A.E., Bedford (see pages 4-5 and 18-20), the following are among those making major contributions:—

The 8ft Tunnel. Higgs and Hill (buildings), Costain-John Brown (working-section and supersonic diffuser), Alexander Findlay (steel frames), Whessoe (design and construction of tunnel shell), English Electric (compressor, drive equipment and generating plant), G.E.C. (control system for flexible walls).

The 3ft Tunnel. Geo. Wimpey (buildings), Whessoe (structural design, fabrication and erection of tunnel shell), English Electric (installation of German compressor plant and drives).

The 13ft × 9ft Tunnel. F. G. Minter (buildings and tunnel shell), G.E.C. (driving motors), Head Wrightson (steel fan section), English Electric (plant for driving model motors and control equipment).

Vertical Spinning Tunnel and High-speed Laboratory. Whessoe (structural design, fabrication and erection of tunnel shell), English Electric (fan drive), Geo. Wimpey (buildings), B.T.H. (compressor), Airscrew Co. and Jicwood (fan).

Other major contributors in many aspects included Daniel Adamson, Baldwin and Francis, Birlec, Brookhirst Switchgear, Cambridge Instrument Co., Davenport Engineering, Denco Engineering Services, Howard Farrow, Film Cooling Towers, Gwynnes Pumps, Matthew Hall, James Howden, Keelavite Rotary Pumps, J. L. Kier, John Laing, London Electricity Board, Major Equipment, Markham and Co., Metropolitan Vickers, Opperman Gears, Pulsometer Engineering, Pye, A. Reyrolle, and Silica Gel.

E. K. Cole Financial Year

PRELIMINARY figures issued by the directors of E. K. Cole, Ltd., in advance of the company's annual general meeting—to be held at the Queen's Hotel, Westcliff-on-Sea, on July 23—show a net profit of £359,074 (1956, £328,733) after allowing for taxation £460,500 (1956, £445,000).

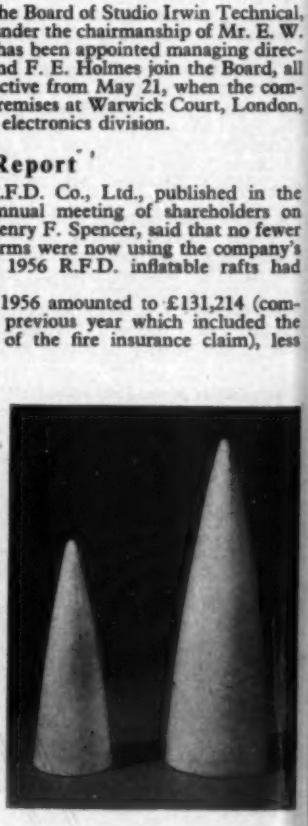
Studio Irwin Changes

FOLLOWING changes in the Board of Studio Irwin Technical, Ltd., the company is now under the chairmanship of Mr. E. W. Hunt, while Mr. R. F. Stock has been appointed managing director. Messrs. J. H. Pennock and F. E. Holmes join the Board, all these appointments being effective from May 21, when the company moved into additional premises at Warwick Court, London, W.C.1, to accommodate their electronics division.

R.F.D. Directors' Report

IN his statement on the R.F.D. Co., Ltd., published in the directors' report to the annual meeting of shareholders on June 21, the chairman, Mr. Henry F. Spencer, said that no fewer than 38 airlines and charter firms were now using the company's survival equipment. During 1956 R.F.D. inflatable rafts had saved 73 lives.

The group's net profit for 1956 amounted to £131,214 (compared with £147,637 for the previous year which included the sum of £26,886 on account of the fire insurance claim), less £75,662 taxation thereon.



These ceramic radomes have been produced by the electronics division of Microcell, Ltd. (Imperial Buildings, 56 Kingsway, London, W.C.2), as a contribution to research on guided-missile nose-caps which must be transparent to radio waves and capable of withstanding high surface-temperatures and erosion.

On her recent visit to New York, after taking part in the International Naval Review at Hampton Roads, Virginia, the aircraft carrier H.M.S. "Ark Royal" makes way proudly up the North River with her crew smartly manning ship.

SERVICE AVIATION

Royal Air Force and Fleet Air Arm News

Standard for 41 Sqn.

ON Sunday, July 14, the birthday of No. 41 Sqn., a Standard is to be presented to the squadron at R.A.F. Biggin Hill by Air Marshal Sir Theodore McEvoy, who is Chief of Staff at H.Q. Allied Air Forces Central Europe and flew with 41 Sqn. from 1925 to 1928. The ceremony —which starts at 11.15 a.m. and will be followed by a short flying demonstration —is to be attended by M. Pierre Gurllain, Mayor of St. Omer, where in 1916 the squadron had its first operational base. M. Gurllain will be presented with a replica of the squadron badge.

R.A.A.F. Research Lincoln

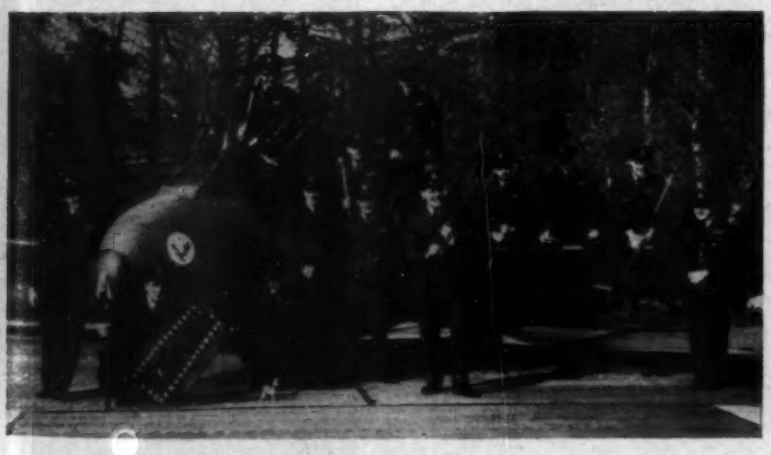
A LINCOLN of the R.A.A.F., fitted with cosmic ray recording equipment, is to make a number of research flights over the Pacific and Antarctic Oceans for International Geophysical Year research. The Australian Minister for Air, Mr. F. M. Osborne, said it would make the flights between July and December over an area from 15 deg North of the equator to 57 deg South, at 20,000ft. The Lincoln's special equipment will collect data on cosmic ray bombardment of the earth's atmosphere for the physics department of the University of Tasmania.

Manchester Win D.H. Trophy

IN what is believed to have been the closest contest of the five so far held for the de Havilland Trophy between the university air squadrons of Manchester, Birmingham and Liverpool, Manchester U.A.S. won the 1957 competition at R.A.F. Woodvale last Saturday by scoring 908 points against 902 for Birmingham and 892 for Liverpool. So keen and precise was the flying—which includes spot landings, formation flying, and solo aerobatics—that the judges (G/C. R. V. McIntyre, S/L. K. A. Perkin, and Mr. J. Corby of the de Havilland Aircraft Co.) found it difficult to choose the winner and said afterwards that the flying throughout had been of a markedly high order.

Among special guests attending the occasion were A.V-M. H. V. Satterly, A.O.C. No. 64 Group; the Vice-Chancellors of Manchester and Liverpool Universities (Professor Mansfield Cooper and Sir James Mountford); and the Vice-Principal of Birmingham University, Prof. A. P. Thomson. The trophy—a silver model of a Chipmunk—was presented to the officer commanding Manchester U.A.S., S/L. J. T. Pinnington, by Mrs. Corby. This is the second successive contest Manchester have won.

Pilots of No. 266 (Rhodesia) Sqn. at R.A.F. Wunstorf, Germany, with their C.O.'s Venom F.B.4 and an assortment of other Rhodesian weapons used for ground attack. Standing on the wing are F/L. R. S. Bingham and F/O. B. F. Raffle; sitting on it are F/O.s G. Eckersley, W. H. Fergus, R. C. Morris, J. A. Farrington and D. F. Webb. In front are F/L. J. G. Huggins, F/O.s S. Ferreira, J. C. Allen, C. F. White and B. D. Duplessis, S/L. G. R. Baxter (C.O.) and F/O. D. G. Bebington. "Flight" photograph



Senior Appointments

TWO Air Officer appointments, and the appointment of a Deputy Air Secretary at Air Ministry, were announced recently. A.V-M. M. L. Heath, C.B., O.B.E., is to be A.O.C. British Forces, Arabian Peninsula, from October; A.V-M. C. E. Chilton, C.B., C.B.E., is to be A.O.C. Malta (as announced in *Flight*'s special issue on the R.A.F. last week, p. 888) from November, with the acting rank of Air Marshal; and A. Cdre. R. A. R. Rae, O.B.E., is to become Deputy Air Secretary at Air Ministry from July—in succession to A.V-M. Heath—with the acting rank of Air Vice-Marshal.

Prior to becoming Deputy Air Secretary, A.V-M. Heath was Director General of Personnel (II) from August, 1955. Since 1934 he has been an armament specialist, and after armament duties at various units was appointed in January, 1943, to command No. 10 Air Gunners School. From 1944-45 he commanded the bomber station at Metheringham, Lincs, and in 1946-47 he became the first Deputy Director of Armament Policy and Planning, and then Director of Weapons (I) at Air Ministry. After a jet refresher course in 1952 he commanded R.A.F. Lindholme, and after taking the 1954 Imperial Defence College course, he became Director of Plans.

A.V-M. Chilton, whose appointment as A.O.C. Malta carries with it the NATO post of Air Deputy to the C-in-C. Allied Forces Mediterranean, has been S.A.S.O. at H.Q. Coastal Command since March

"Flight" photograph

When this composite Javelin/Hunter formation was depicted last week a garbled caption misrepresented the squadrons concerned. The Javelins, in fact, belong to No. 141 Squadron (W/C. P. L. Chilton, D.S.O., D.F.C., A.F.C.), and the Hunters to No. 74 Squadron (S/L. K. N. Haselwood).

SERVICE AVIATION . . .

1955 and before that was A.C.A.S. (Policy) from September 1953. He qualified as a specialist navigator at Calshot in 1931 and early in the war was in charge of the navigation branch at Air Ministry. In 1942 he became Group Captain i/c Training at H.Q. Flying Training Command; in 1943 he commanded R.A.F. Chivenor and in 1944 he took over a special appointment at Plymouth to plan anti-U-boat operations by the R.A.F. and the R.N. for D-day, for which he was later awarded the C.B.E.

A. Cdre Rae, who is an Australian, has since April 1955 commanded R.A.F. Boscombe Down and was previously Deputy Director of Flying Training at Air Ministry. After armament duties in the Far East from 1937 he was appointed in 1942 to command R.A.F. Tengah, Malaya, but in 1943 was reported missing and was subsequently found to be a prisoner of war. After his liberation in 1945 he joined the Empire Air Armament School at Manby, Lincs, and he has since held command at the Central Gunnery School at Leconfield, R.A.F. North Luffenham, and No. 206 Advanced Flying School at Oakington, Cambs.

R.A.F. Appointments

BELOW is continued a list of R.A.F. appointments recently announced by the Air Ministry:—

G/C. A. A. Fletcher to Air Ministry, for duty in the Department of the Air Member for Supply and Organisation; G/C. D. Price to R.A.F. Stoke Heath, to command: G/C. G. P. Seymour-Price to the Ground Officers' Selection Centre, R.A.F. Uxbridge, as Commandant; G/C. E. A. Johnston to R.A.F. Topcliffe, to command; G/C. K. T. Nicklin to H.Q., Middle East Air Force for administrative staff duties; G/C. R. R. Goodbody to No. 93 Maintenance Unit, to command; G/C. J. C. Pope to H.Q. No. 3 Group, for technical staff duties.

W/C. H. N. Phillips to R.A.F. Kenley, to command; W/C. R. I. M. Bowen to H.Q., 2nd T.A.F., for air staff duties; W/C. R. R. Chapman to the R.A.F. Regiment (Malaya) Wing H.Q., to command; W/C. P. L. Crowell to R.A.F. Marham, for technical duties; W/C. J. F. Hatton to Air Ministry, for duty in the Department of the Air Member for Personnel; W/C. F. W. M. Jensen to the School of Land/Air Warfare, to instruct; W/C. M. W. Coombes to H.Q. Southern Sector, for Air Staff duties; W/C. T. Balmforth to R.A.F. Goch, for operations duties; W/C. P. S. Hall to H.Q., No. 41 Group, for technical staff duties; W/C. C. W. Kemp to H.Q., Coastal Command, for technical staff duties; W/C. D. W. T. Withers to R.A.F. Heywood, for equipment duties; W/C. B. N. Keeling to H.Q. Technical Training Command, for administrative staff duties; W/C. J. MacDonald to H.Q. Bomber Command, for administrative staff duties; W/C. S. R. Williams to R.A.F. St. Athan, for administrative duties; W/C. J. O'Neill to R.A.F. Heywood, for equipment duties; W/C. B. B. Johnson to H.Q. No. 40 Group, for equipment staff duties; W/C. C. H. Beeton to A.A.F.C.E. for staff duties; W/C. R. J. Macleod to H.Q. Home Command, for staff duties; W/C. A. J. Peart to R.A.F. Khormaksar, for technical duties; W/C. A. F. Hamilton to R.A.F. St. Athan, for administrative duties; W/C. J. E. Holland to R.A.F. Wattisham, for flying duties; W/C. R. P. S. Wyrill to H.Q. Transport Command, for administrative staff duties.

S/L. B. A. Primavesi to Air Ministry, for duty in the Department of the Air Secretary (with acting rank of wing commander); S/L. G. M. McMinn to H.Q. Fighter Command, for technical staff duties (with acting rank of wing commander); S/L. A. J. Harvey to Air Ministry, for duty in the Department of the Air Member for Personnel (with acting rank of wing commander); S/L. M. D. Logan to Air Ministry, for duty in the Department of the Chief of the Air Staff (with acting rank of wing commander); S/L. T. J. Coggin to H.Q. No. 40 Group, for administrative staff duties (with acting rank of wing commander); S/L. F. W. Dowling to Air Ministry, for duty in the Department of the Air Member for Personnel (with acting rank of wing commander).

IN BRIEF

The Queen has approved that aircrew officers and ratings affected by the disbandment of the R.N.V.R. Air Branch shall be given a concession reducing the length of service necessary for them to qualify for the Volunteer Reserve Decoration and Clasp and the Long Service and Good Conduct Medal and Clasp. Official regulations concerning this concession may be obtained from the Admiral Commanding Reserves, The Admiralty, Queen Anne's Mansions, London, S.W.1.

* * * * *

A trophy has been donated to the R.A.F. Technical College at Henlow by the de Havilland Aircraft Co. Taking the form of a silver model of a Chipmunk (the training aircraft used at Henlow), mounted on an inscribed plinth, it is awarded to the best student pilot in each entry.

* * * * *

Ten R.C.A.F. Sikorsky H-19 helicopters from No. 108 Communications Flight, Rockcliffe, Ontario, have been loaned to Okanagan Helicopters, Ltd., of Vancouver, for use in constructional work on the Mid-Canada Early-Warning Line.

Aviation Traders' Accountant (seen here less its propellers and anti-spin parachute fairing) is shortly expected to make its first flight. Engine-runs and taxying tests have been successfully completed.

CIVIL AVIATION

CARAVELLES FOR S.A.S.

A MOMENTOUS event for the French Sud Aviation concern, and for Europe's airline industry, was last week's order by S.A.S. for six Caravelles. This is the first export order for the aircraft, 12 of which have been bought by the national airline Air France. The S.A.S. Caravelles will be delivered between April and October 1959, and will go into service in the summer of that year. S.A.S. have a further 19 Caravelles on option, for delivery between 1959 and 1963.

The choice of the Caravelle by an airline of the standing of S.A.S. is portentous. It means not only that the airline has rejected the turboprop as the answer to its short-haul and medium-haul needs; but also that S.A.S. have decided not to wait until 1963 for the specialized, "new plateau," 600-m.p.h. short-haul jet. S.A.S. may—and almost certainly will—order such an aircraft in due course.

The order may presage a swing towards the jet in the medium-haul deliberations of S.A.S.'s European competitors. B.E.A., for example, operate services to Scandinavia (Copenhagen, Stockholm, Oslo and Bergen) in pool with S.A.S.; but pool agreements are subject to abrogation, and a partner operating an aircraft as highly competitive as the Caravelle may be tempted to try for a larger slice of traffic. This is why B.E.A. have been examining not only their requirements for the 1963, 600-m.p.h. jet, for which Bristol, Avro and de Havilland all have projects: they are considering also, as reported on page 2, a fleet of de Havilland Comet 4Bs to serve them in the interim.

ANTIPODEAN TRAFFIC RIGHTS

QANTAS were last week granted—in spite of the A.T.A. of America's vociferous protests about what they called the U.S. State Department's "give-away" policy—the trans-U.S.A. extension from San Francisco to New York that they so badly wanted. By entering the competitive fray over the North Atlantic they can now establish a unique round-the-world service that embraces five continents. The airline's chairman, Sir Hudson Fysh, described the new concession as "the most significant event in Australia's overseas transport for more than 20 years"—since the England to Australia air route was opened. He added that Qantas' Boeing 707-138s would be used on both routes—eastward and westward.

Australia appears to have bargained almost to the limit to obtain this route, and has granted the U.S.A. rights to Australia *via* Antarctica, across Australia to Darwin and Singapore—and across Australia to Johannesburg. A contentious U.S. request—which caused a storm across the Tasman Sea—was to route PanAm's Australian service *via* New Zealand, with traffic rights between the two Commonwealth countries. Mr. Thomas Shand, New Zealand's Minister of Civil Aviation, said that T.E.A.L. [in which Australia and New Zealand are equal partners] would be seriously affected by any arrangement amending its traffic rights."

Three Scottish Aviation Twin Pioneers of de Kroonduif in formation over the Ayrshire coast before being delivered to New Guinea. They left Prestwick on June 26 flown by the manufacturers' pilots but with K.L.M. co-pilots and engineers included in the crews.

NEW INDEPENDENT OPPORTUNITIES

WE referred recently to "promising new recommendations" laid before the Minister by the Air Transport Advisory Council —promising, that is, from the viewpoint of Britain's private airlines. These recommendations, made public on June 26, have been accepted by Mr. Harold Watkinson.

The immediate implications are that Airwork and Hunting-Clan (the companies most affected) can at last operate modern aircraft —including Viscounts—on their colonial-coach services to Nairobi and Salisbury. Furthermore, because Ghana is no longer a colony and colonial-coach services are not applicable there, tourist-fare services at I.A.T.A. rates can be flown to Accra *via* the West African route (Bathurst and Freetown) with "no restriction" on the type of aircraft. This no doubt includes the Britannia, two of which are on order for Hunting-Clan for May 1958 delivery.

Neither Airwork nor Hunting-Clan can yet say when Viscounts or Hermes will be introduced, but it is significant that the three Viscounts leased to Middle East Airlines by Hunting-Clan are due to be returned in about twelve weeks' time. Airwork of course sold their Viscounts to Cuba, and as yet have no others on order.

The longer-term implications of the new recommendations are that both Airwork and Hunting-Clan will be given a combined 30 per cent share of the new I.A.T.A. third-class-fare traffic (*alias* T.34 traffic) when it spreads to Africa from the Atlantic, where it is to be introduced nine months hence. The other 70 per cent will be taken by B.O.A.C., who will also have the exclusive British share of the "higher-class" traffic.

No one knows how quickly third-class fares will spread to Africa, or whether they will attract existing tourist-type passengers. Thus the value to Airwork and Hunting-Clan of a 30 per cent share of third-class traffic (which will of course replace their colonial-coach services) must remain in doubt. But it is a step in the right direction: "thrift-fare" traffic is a class of business towards which world air transport is steadily moving and, according to the A.T.A.C. recommendations, there will be "no restrictions" on the kind of equipment Airwork and Hunting-Clan can use to carry it. This suggests that the two companies are now in the market for whatever transport will be suited to the routes. It appears not beyond the bounds of possibility that British independent airlines may soon be in a position to place orders for such aircraft as the DC-8, 707 and VC-10—a possibility which only a few months ago seemed remote. At long last Britain's two leading independent airlines (both, incidentally, members of I.A.T.A.) can really get down to some long-term planning.

There is good news, too, from the trooping-contract front. Transair, whose two Viscount 804s are due for delivery in August, have won a contract from the Government to operate their Viscounts on trooping flights to the Mediterranean from October 1. The contract was, presumably, tendered for in competition with operators of twin-piston-engined aircraft. Transair's success is a vindication of their long-standing "calculated-risk" order for Viscounts, and a fulfilment of the Air Minister's promise in Parliament on May 9 that, where possible, future trooping contracts would be placed with the independents and that trooping would be done with modern aircraft. Transair (an Airwork associate) have a number of applications before the A.T.A.C. for the use of Viscounts on scheduled and inclusive-tour services also.

CIVIL AVIATION . . .

C.A.A. AND BRITANNIA'S UNDERCARRIAGE

THE A.R.B.'s annual report (summarized on page 12) only lightly hints at differences of outlook between the A.R.B. and the Civil Aeronautics Administration. Typical of these seems to be the modification required by the C.A.A. to the main undercarriage gear of the Britannia 305s ordered by Northeast Airlines. The American publication, *Aviation Daily*, reports that the development of new and strengthened gear as required by the C.A.A. is taking slightly longer than expected, so that Northeast's first Britannia—to be used for crew-training only—is likely to be delivered (around November 1) with the standard undercarriage. Two more Britannias would be delivered later that month with modified gears for passenger service.

The American report states that Northeast had asked C.A.A. to allow Britannias to be used with the standard undercarriage for passenger-carrying duties for a short period, but permission had been refused.

The Britannia's undercarriage is, of course, the first bogie gear to have come up for C.A.A. approval, and it appears that the "differences" relate to the requirements for short-radius turns.

RECORD MAY FOR B.E.A.

THE two hundred millionth Viscount 700 passenger was carried during May by B.E.A., who have achieved this figure in just over four years of operation. During that month also another "important landmark" (as Lord Douglas puts it) was passed with the carriage, for the first time in B.E.A.'s history, of two-and-a-half million passengers within a year.

Discussing the May results, Lord Douglas announces that B.E.A. will operate all its Channel Islands services through Gatwick as from April 1958, when the airport is due to be re-opened. The Corporation in the meantime looks forward to the opening of the new Air Terminal in Cromwell Road on October 6.

AVRO'S JET PROJECT FOR B.E.A.

"A DETERMINED attempt to enter the civil airliner markets" is referred to by Sir Roy Dobson, managing director of A. V. Roe and Co., Ltd., in the current issue of *Avro News*. The company's projects design team has, he says, developed a design for a jet airliner to B.E.A.'s specification. It would be an aeroplane designed to cruise at 600 m.p.h. over ranges of up to 1,500 miles. "There are," he says, "other aircraft companies in this design competition and we cannot afford to underestimate the opposition. It will be keen—very keen." Sir Roy expresses confidence in the firm's ability and production facilities and the tremendous fund of research knowledge available to it. "An important fact to remember," say Sir Roy, "is that we are risking many millions of our own money in this venture, so it had better be successful. . . ."

WHISPERING SIMULATOR

SO expensive has airborne training become that elaborate and expensive flight simulators quickly pay for themselves. A spate of orders for such units has been placed by airlines during the past year. B.O.A.C.'s simulator for the Britannia 102, manufactured by Redifon, Ltd., of Crawley, is one of the most elaborate in use. Accommodated on the fourth floor of the B.O.A.C. building at London Airport, it provides a 30 hr introductory training course for new Britannia crews, and it is used also for refresher training. *Flight* examined it on a recent Sunday, the simulator's day off.

In the cockpit, an almost exact reproduction of the real thing, the pilot, co-pilot and engineer under training are supervised by a pilot-instructor and an engineering-instructor with extensive Britannia flight experience. Pilots are first given a spell in the separate one-man flight-trainer—a simplified device for instructing the pilot in his own particular task before subjecting him to the full workload of Britannia operation.

Aft of the cockpit of the simulator is a radio-aids compartment controlled by an instructor who fulfils the functions of the airfield control tower, airfield approach, control centre, and any number of flight information regions. He is a very busy man, as he monitors also all the aircraft's radio (duplicated V.H.F.s, M.F., H.F., I.L.S., D.M.E., and so on).

Airworthiness certification of the AW.650 Freighter-Coach was the topic for discussion during a recent visit to Baginton by A.R.B. and C.A.A. officials. They are seen here with senior A.W.A. engineers.

The instructors can "fail" any facility to test emergency drills. A very high standard of operational efficiency can, and is, reached. The workload applied is, of course, likely to exceed anything that the crew will meet down the route (see Capt. Houston's account of Britannia training in our February 1 issue).

The Britannia simulator is realistic enough for crews to forget that they are not airborne. The engine-sound is reproduced, the control feel is representative, and the nosewheel rumbles during take-off and taxying. The simulator even smells like a Britannia.

Two similar units have been ordered from Redifon by C.P.A.L.

THOSE ELUSIVE TARGET-DATES

NOTHING is more perishable than the testing and delivery programme of a new aeroplane, and manufacturers have reason to be reticent about publishing target-dates. This seems a pity, because to put a target-date on view to the world is a stimulus towards achieving it.

There are exceptions in the British industry. Mr. Peter Masefield is on record as having said of Britannia production: "As long as you have a date on everything you know where you are going and can take action before it is too late."

The policy of the programme-conscious Americans is to publish all target-dates. These can be regarded with amusement, scepticism, or confidence, depending upon one's views: but they at least convey a sense of purpose. The present target-dates for each major stage in the development of the Boeing 707, Convair 880, Douglas DC-8 and Lockheed Electra, as they stand today, are as follows:—

	Roll-out	First flight	Start of C.A.A. flight tests	C.A.A. Certification	First delivery
Boeing 707-120	Oct. 1957	Dec. 1957	Feb. 1958	Dec. 1, 1958	Dec. 1958
Convair 880 ...	Nov. 1958	Jan. 1959	Aug. 1959	May 1, 1960	Nov. 1959*
Douglas DC-8	Feb. 1958	Mar. 1958	Feb. 1959	Aug. 1959	June 1959*
Lockheed Electra	Dec 1, 1957	Jan. 31, 1958	Apr. 1, 1959	Aug. 31, 1958	Oct. 1958

* Aircraft for crew training.

This is the ex-Capitol Viscount 745D which was re-registered G-APBH and used by Vickers for a demonstration visit to the U.S.A. last month. As a result, strong interest appears to have been shown by T.W.A. in the 15 ex-Capitol off-the-shelf Viscounts.

CIVIL AVIATION . . .

The Future of the Flight Engineer

PRESENT controversy about the place of the flight engineer in the modern airliner cockpit (see particularly "Flight" for March 15, reporting the B.O.A.C. Britannia dispute) has prompted Mr. George R. Petty, Jr., Vice-President Engineering of the Flight Engineers' International Association (Washington, D.C.) to send us this letter. It is the strongest case yet put for the preservation of the flight engineer.

I AM one of many Americans (writes Mr. Petty) who have been reared properly, that is to say, with a predisposition to admire all things British, even when they may be wrong. Sadly, I have found this predisposition strained, of late, with regard to your excellent magazine; and for that reason I feel obliged to comment upon some remarks made in your columns concerning the flight engineer and his position in gas turbine powered transports.

To begin, I have acquired the impression that the British industry questions the value of our U.S. civil air regulation which requires the carriage of a flight engineer on all aircraft over 80,000 lb gross weight. I am sure it will be recognized that this figure was set in order to draw a dividing line between the DC-4 and DC-6. I think that in any discussion of the difficulty involved in flying an airplane it will be admitted that the problems of the pilot increase as the wing loading increases and, further, that they increase as the power to weight ratio decreases. Furthermore, the workload of the pilot will increase as block speed increases over the same average stage length, because of the greater number of landings and take-offs per hour of flight. To summarize then, the difficulties of pilotage are proportional to $2V_bW^2$ divided by the average stage length times the wing area times the thrust, i.e.,

$$\frac{(2V_bW^2)}{D_sAF_n}$$

Since the pilots' troubles apparently increase with W^2 it is entirely appropriate that the gross weight be selected as the parameter by which we will determine when he needs help. The Civil Aeronautics Board decided on the basis of empirical evidence that the point on this curve where the pilot's need for help was such as to require a flight engineer was somewhere between the gross weight of the DC-4 and the gross weight of the DC-6; and, consequently, they selected the figure of 80,000 lb as the divider. At the selected point the mass of the complex machine exceeded the ability of the two-pilot crew to cope with it under all conditions.

Maintenance record comparing K.L.M. Convairs with flight engineers to Convairs of European operators not using flight engineers—data for April 1955.

	K.L.M. Convair 240	K.L.M. Convair 340	European Convair Operators
Number of aircraft (average)	7	10	4.7
Daily utilization	4 hr 36 min	5 hr 27 min	4 hr 31 min
Number of take-offs per 1,000 hr ...	959	625	792
Number of technical delays per 1,000 hr	11.4	10.6	30
Ratio of delays to take-offs	1 to 84.3	1 to 58.7	1 to 26.3
Delays per 1,000 flight hours:			
Engines	1.2	1.2	2.3
Ignition system	1.8	0.7	2.1
Fuel system	0.8	0.6	0.9
Prop. control system	0.7	1.1	1.3
Electrical system	1.6	2.7	3.2
Instruments	1.7	0.4	3.2
Air conditioning	0.2	0.4	0.9
Hydraulic system	1.3	0.9	2.4
Aircraft	1.3	1.6	4.1
Radio	0.5	0.4	3.6
Miscellaneous	—	0.5	2.6

The Civil Aeronautics Board arrived at their decision in favour of retaining the flight engineer after public hearings in the fall of 1947 at which every segment of the American aviation industry was represented. The previous years had seen the newly introduced DC-6 involved in accidents which suggested the need for such a crew member, in spite of the fact that at the time of the regulation's introduction the DC-6 had 1,600,000 flying hours to its credit. The U.S. Air Line Pilots' Association at that time supported the Board's proposal for the addition of the flight engineer to the crew of four-engined aircraft. The Air Transport Association of America submitted a brief which among other things stated the opinion that the determination of crew complement was a function only of airline management, not of civil air regulations. The Civil Aeronautics Board refuted this contention and in effect took jurisdiction over the determination of minimum crew requirements for transport aircraft.

In explanation of its decision the Board stated in part: "As a result of this testimony the Board has concluded that the multiplicity of instrumentation and complexity of controls on certain of these aircraft limit the pilot's ability to focus his attention on all of the critical instruments and controls. It is believed that a competent flight engineer, by assuming certain mechanical duties, will enable the pilot to concentrate his attention on the actual flight of the aircraft, radio operation, and receipt of traffic control clearances, particularly during instrument conditions where this is imperative." Implicit in this decision and the language used in the Board's explanation are the following considerations concerning the flight engineer's duties:—

(1) The duties of the flight engineer cannot properly be performed by a third pilot crew member. Apparently the Board felt that a different set of qualifications, especially of a mechanical nature, were required of a flight engineer, and accordingly new requirements were established for the training, examining and licensing of flight engineers.

(2) The division of duties in the cockpit into pilot functions and flight engineer functions, based upon the type of experience required to perform them, is a practice required in the interests of safety.

(3) Flight engineering is a separate craft from piloting.

(4) The flight engineer assumes a degree of responsibility for maintenance work in flight, and—to the extent that an aircrew is consulted on accepting the airworthiness of aircraft—on the ground. Before the requirement for a flight engineer, the maintenance group on the ground had to deal with the captain only, whose understanding of larger and more complex aircraft might be limited to the point where he lacks the knowledge to judge whether the maintenance performed would rectify the troubles (snags) reported.

This decision (wrote the Civil Aeronautics Board) has received important support just recently from Mr. D. P. Davies, D.S.C., chief test pilot of the Air Registration Board, who, in a lecture to the Royal Aeronautical Society, reported in *Flight* for November 30 last year, favoured the use of the flight engineer on any large aircraft with passengers aboard. To quote from the *Flight* summary (said the C.A.B.), *It was his opinion that the airline captain should be given no more than the primary flying controls and trimmers, brakes, steering, flight instrument panel and primary power controls and indicators. All the rest of the engineering should be given to the engineer, and all the secondary aircraft controls to the second pilot. The engineer should have a "properly equipped station." The difficulty here had arisen because of the differences between minimum and operational flight crews. "An aircraft should be designed not for a minimum flight crew, but for the operational flight crew." It was of academic interest only that large aircraft could be ferried by two pilots, and attempts at two-crew layouts had resulted in a generally unsatisfactory operational layout. He "viewed with suspicion" the tendency to reduce crew number and the corresponding increase in workload.*

Similar opinions have been advanced in the United States with regard to gas turbine powered aircraft by Captain B. A. Martin, chief test pilot of the Lockheed C-130. Capt. Martin stated to a jet study group from the Air Line Pilots' Association that "besides a pilot and a co-pilot, the operation of the aircraft required a man who would have an understanding of its various systems and be able to troubleshoot and by-pass inoperative components. Some examples of the systems that need monitoring of a fairly constant nature are: the powerplant, the electrical system, the pressurization system, the propeller system, the pneumatic system, the fuel system, and electronics system." It was Capt. Martin's view that the third crew member or flight engineer would be the systems co-ordinator, and would need more mechanical know-how than had been required of a pilot. One aspect of his concern for the properly trained "systems co-ordinator" is that special abilities and inclinations are needed for the job. As he sees it, there is a need for the third crew member to have an inclination toward operation and analysis of electronic, electrical and other mechanisms which seem to be growing more complicated each day. The emergency operation of some systems with various components inoperative requires detailed knowledge of those systems so that maximum utilization of the remaining components will be possible under all flight conditions.

TABLE 1

Relative complexity of commercial aircraft as shown by the total number of displays, controls, switches, etc., in the cockpit (including radio switches, but not including circuit breakers and fuses).

	DC-3	Martin 404	T.C.A. Viscount	T.C.A. Vanguard	DC-6B	L.49	L.1049G	DC-7	B-377	Electra	707 A.A.L.
Pilots' panels, or total if no engineering panel	208	259	322	343	466	238	255	538	235	518	345
Engineering panel ...	—	—	—	—	—	244	274	—	331	—	209
Total	208	259	322	343	466	482	529	538	566	518	554

Civil Aviation

The Future of the Flight Engineer . . .

But despite the claims of operational simplicity for gas turbine powered transports, a study of the American Airlines cockpit mockup of the Boeing 707 shows that there are more switches, instruments and controls in that airline's 707 than there are in its DC-7 (see tables). If this type of analysis can be used to estimate crew work load (as it has been in the past), the argument for the functional simplicity of the gas turbine transport cockpit collapses completely.

There have been many efforts by designers to simplify the control of aircraft systems by the use of remote electrical or electronic controls—in a word, by automation. At the same time designers have been aware of an increased need for reliability in high-altitude, high-speed transports and this has worked in direct opposition to their intention to simplify. In all cases the result of efforts made in the direction of control simplification and system reliability has been to increase the need for maintenance capability in the cockpit. The addition of a third, fourth, fifth or twentieth junior pilot to the crew can never add this type of background and experience to the sum of knowledge in the cockpit.

It can be shown that the flight engineer provides this extra margin of safety and reliability at no extra cost to the airline involved, for by his presence in the cockpit he can insure the schedule reliability and rapid transiting of jet aircraft through route stations which will be required for their profitable operation. For instance, situations will arise where the presence of the flight engineer can prevent an unnecessary turn-back after a maximum gross weight take-off, which on the DC-8 would save the airline $2,279.00 (the cost of 97,000 lb of jet fuel that would have to be dumped to bring the aircraft down to maximum landing gross weight). Such a situation could arise from the partial failure of the electrical system, the pressurization system, or perhaps the hydraulic system, which with an all-pilot crew could conceivably develop into trouble of serious proportions, but with a flight engineer might be minimized to the point where the continuation of the flight was possible. That the flight engineer can do this job can be demonstrated from the records of K.L.M., Pan American World Airways, Trans World Airlines or any of the airlines all over the world which employ mechanical specialist engineers in such a way as to make the best use of their skills.

In support of his contentions, Mr. Petty supplies an actual maintenance record (p. 31, col. 1) of flight-engineered Convairs of K.L.M. compared with non-flight-engineered Convairs of other European operators, to demonstrate the economic value of the flight engineer. Convairs *without* flight engineers had almost three times as many technical delays per 1,000 hr as Convairs on comparable routes *with* flight engineers.

I feel (he adds) that *Flight* should hesitate to condemn the flight engineer as a victim of technical progress when it is he, and he alone, who can ensure the success of the more complex innovations in jet transports.

It has been the contention of manufacturers and others (Mr. Petty continues) that an era of simplicity of aircraft operation and handling is upon us. Boeing, for example, in their world-wide advertisements, have stated that there are 160 fewer switches on the 707 than on a corresponding piston-engined transport. For comparison, they used the B-377 Stratocruiser. They counted 565 controls and displays in this aircraft, and, by contrast, 305 controls and displays in the 707.

We set about to discover how these figures were developed. We contacted the man responsible for the survey, a Mr. Eugene Norris, a sales engineer in Boeing's Washington office, and in the course of our discussions the following facts emerged:—

(1) The survey was made in 1954. (2) The count for the 707 was made by adding up the number of controls and displays on a then-current mock-up of the KC-135 tanker, subtracting from this figure the number of switches on the tanker re-fuelling panel, and adding nine warning lights for commercial use. (3) The count of the 707 did not include radio switches. (4) Mr. Norris was willing to admit that his "complexity survey" was obsolete; that it did not apply to any 707 cockpit proposed for the airlines today; and that no doubt there were many more controls and displays in the 707 cockpit now.

We then made a survey of our own. For comparative purposes, we included twin-engined transports as well. Results of this survey are summarized in Table 1 on the previous page.

The 707 has only 11 items fewer than the Stratocruiser, and *more* than the DC-7, L.1049G, DC-6B, etc. But the case for the flight engineer in the big jet transports emerges most strongly from a system-by-system comparison of the 707 with piston transports. Thus:—

TABLE 2

System by system comparison of number of cockpit controls of 707 mock-ups using A.A.L. DC-6 as standard index (100 per cent).

System	P.A.A.-707	A.A.L.-707
Electrical	170	170
Hydraulic	138	113
Fuel	144	144
Powerplant	61	64
Air conditioning and pressurization	83	139
Fire control	37	39
Oxygen	260	290
Radio	89	114
Flight instruments ...	95	111
Overall	101	117

TABLE 3

Number of controls and displays for various aircraft by systems.

	DC-6B	DC-7	B-377	Electra	P.A.A.-707	A.A.L.-707
Electrical	37	45	41	47	63	63
Hydraulic	24	25	11	29	33	27
Fuel	39	40	38	41	56	56
Powerplant	90	117	134	116	55	58
Air conditioning and pressurization ...	38	48	36	36	30	50
Fire control	46	45	67	29	17	18
Oxygen	7	7	17	9	18	20
Radio	79	96	—	88	71	90
Flight instruments ...	45	42	—	56	43	50

BREVITIES

DURING its two-month tour of North and South America, just completed, the Caravelle made 94 demonstration flights. These were for six Brazilian operators, four airlines in Argentina, three in Venezuela, 32 in the U.S.A., and two in Canada. About 3,000 people flew in the aircraft.

* * *

Silver City announce a £50,000 extension at Lydd Airport (Ferryfield), to increase passenger handling capacity by 50 per cent.

* * *

New orders for Fokker Friendships, states an unofficial report, come from Wien Alaska, 3; Butler Aviation, 1 (previously reported as five); Bank of Mexico.

* * *

The Pacific Western DC-3 accident after take-off at Port Hardy, British Columbia, on June 23 is believed by the airline to have been caused by failure to remove elevator control-locks.

* * *

Derby Aviation have received approval for inclusive-tour services this summer between Blackbushe and Calvi (Corsica), and Manchester, Birmingham and Perpignan.

* * *

Official name of Austria's new airline is the Austrian Airlines Corporation. The Government will provide 70 per cent of the capital, S.A.S. and Fred Olsen providing 15 per cent each.

Plans are in hand for a new terminal building at Prestwick airport. Work is to start this year on a new control tower.

* * *

Aer Lingus inaugurated their Dublin - Manchester - Zurich - Rome Viscount service on June 28.

* * *

Morton Air Services of Croydon are authorized to offer a 12-guinea return fare from Croydon to Rotterdam. They have introduced a Heron (G-AOXL, ex-Garuda) on to the service.

* * *

The U.S. government is being sued for $2,400,000 by executors of two passengers killed in the Grand Canyon crash in June 1956. Other suits have named the airlines concerned, T.W.A. and United.

* * *

The co-pilot of a T.W.A. Super Constellation *en route* from Chicago to Denver made an emergency landing at Grand Island after the captain suffered a fatal heart attack.

* * *

The British Government has withdrawn Ethiopian Airlines' landing rights at Nairobi. Previously the Ethiopians had withdrawn Aden Airways' rights at Addis Ababa, apparently because of an Aden Government ban on imports from Ethiopia of the narcotic drug qat.